AGÊNCIA NACIONAL DE INOVAÇÃO

CREATION OF A KNOWLEDGE TRANSFER NETWORK IN PORTUGAL

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Strategy document for the creation of the Network - its operation, management, governance, financing and performance evaluation of the Network

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PART 1- Analysis of the Activities of Portuguese TTOs 2015-2016

TABLES

FIGURES

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SUMMARY

The results of a survey of 85 Portuguese Technology Transfer Offices (TTOs), carried out in 2017, was analyzed and documented. The group of 85 TTOs was subdivided into 25 'Academic' TTOs (ATTOs) and 60 'Non-Academic' TTOs (NTTOs) in order that comparisons could be made between these groups.

Portuguese TTOs are relatively young, with a mean age of 11 years at the time of writing and provide a wide range of services. The average size of a TTO is 9.5 FTE, with ATTOs being typically half the size of NTTOs. Only 72% of TTOs are set up to support IP licensing (92% of ATTOs and 63% of NTTOs). The staff employed by TTOs have high levels of formal education, and there is high representation of the disciplines of Engineering and Natural Sciences. The majority of staff have less than 3 years of experience with technology transfer.

The mean annual budget for TTOs is approximately €1.1 million, with NTTOs having a mean of 9.5 times larger budget than ATTOs. The majority of budgets are spent on 'Human Resources', although NTTOs spend proportionally less in this category than ATTOs. Approximately one third of the budget is supplied by the TTO 'parent' institutions (and almost a half for ATTOs). The remainder of the budgets come from 'external services and fees supplied by companies' and 'national co-funded projects'. License income accounts for 4% of TTO budgets.

TTOs service a wide range of Portuguese industry sectors. 62% of TTOs have a relatively narrow sector focus (3 sectors or fewer). The ATTOs work with a wider range of industries than the NTTOs, possibly due to a more diverse range of activities within their parent institutions. The 'Information and Communication Technologies' (ICT) was the most reported industry focus, although there was a relatively even distribution between all sectors described in the survey.

Intellectual property (IP) royalties were received by 27% of TTOs during the survey years, and these were distributed by a variety of mechanisms (including institution retaining all income), indicating that there is no standardized model. Portuguese TTOs filed an average of 6 new patents per office (75% of these from ATTOs); approximately 80% of filings are provisional Portuguese patents and full Portuguese patent applications. The most popular subjects are Biomedical followed by Computers and software and Nanotech and materials. Active patents are held by 37 of the 85 TTOs, with more than 50% of total number held by

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only 3 organizations. The majority of active patents are Portuguese, less than 20% are foreign patents.

TTOs made an average of 3.5 IP agreements (including patent licenses) per year with partners, most commonly a Portuguese partner (around 80%). Most agreements were made with small companies that were not 'start-ups'. NTTOs had more agreements than ATTOs, and 55% of agreements were made by the top 5 TTOs. Total IP license income was €1.3 million per annum for all 85 TTOs, but only 20 TTOs reported any income, and the top 5 TTOs generated 70% of the income. Around 40% of TTOs stated that their IP licenses had resulted in profitable products. The TTOs made 831 R&D agreements per annum with companies.

The TTOs were responsible for 370 new companies per annum, two thirds of these were from NTTOs, and only 8% were owned by the parent institutions. These companies employed a total of 8434 people, the top 3 TTOs reported 71% of these employee numbers. Each new company employed an average of 6 people. The total turnover from these new companies was around €250 million, but only 20% of TTOs provided data. The companies connected to the NTTOs reported 96% of the turnover. The largest number of new companies were in the ICT sector, with other sectors varying in popularity between years and between the ATTOs and NTTOs.

Chapter 0: Background and purpose of the Data Analysis

The purpose of this Analysis is to collate and present data relating to technology transfer activities by Portuguese technology transfer offices (TTOs)

ANI (Agência Nacional de Inovação), the Portuguese National Innovation Agency, in collaboration with FEP (Faculdade de Economia, Universidade do Porto), conducted a survey to all Portuguese infrastructures devoted to technology transfer activities, based on the former surveys by UTEN (University Technology Enterprise Network, UTEN Portugal). The data gathering processed ended on 28th July 2017.

Technology transfer activities include developing new, or improving existing, technologies, and then spreading related information, knowledge, and expertise to the broader society in order to accelerate innovation to advance country's economic, social and environmental well-being, and increase its economic competitiveness.

A report was produced by FEP in 2018 (authored by Prof. A. Teixeira) which provided an analysis of the survey responses from the 25 infrastructures described as 'academic technology transfer offices' (ATTOs), which included Portuguese University TTOs and Polytechnic TTOs. This report is an analysis of the responses from a group of 85 respondents, comprising the 'original' 25 ATTOs plus an additional group of 60 non-academic TTOs (NTTOs). The general descriptions of the organizations that are included in this new analysis are shown in Table 1. Where possible, the analysis shown here follows the format of the 2018 report to allow for relevant comparisons.

The main purpose of this report is to document the technology transfer activities of all 85 TTOs that were included in the 2017 survey, so that they may be used to characterize the performance of these organizations and allow trends to be identified and benchmarks to be established.

Table 1: Types of TTO included in the Analysis for this report.

Type of TTO		Number of responding TTOs	Notes
Academic TTO (ATTO)	Total ATTO	25	
Non-Academic TTO (NTTO)	Integrated TTO	22	1
	External TTO	12	2

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Type of TTO		Number of responding TTOs	Notes
	'Other' TTO	26	3
	Total NTTO	60	
Total TTOs included in the analysis		85	
Notes:	1. A technology transfer office that is an integral part of a parent institution. 2. An external organization or firm that provides technology transfer services to multiple institutions 3. Organizations not falling into type (1) or (2).		

The Academic TTO Group (ATTO) includes 14 State/Public Universities 1 Private University and 10 Public Polytechnic Institutes (total ATTO = 25)

The Non-Academic TTO Group (NTTO) includes a group of 26 organizations described as Technology transfer valorization centers, centers of technological interface which may also be centers of technology-based incubation. The NTTO group also includes 19 technology-based incubation centers (single designation); 5 regional/local incubators and 10 science and technology parks (total NTTO = 60)

The full list of institutions that participated and whose responses are included in this survey is shown in Appendix 1 (pág. 40) to this report.

Chapter: 1. Organization of Technology Transfer Office (TTOs)

1.1 Description of the TTOs

Of the 83 institutions (97.5%) that provided a foundation date for their TTO activities, the largest group was less than 5 years old. When the responding, TTOs were grouped as ATTO and NTTO there was some variation in the percentages of TTOs in the different age ranges, with the ATTOs being established for longer than the NTTOs. The mean ages were: All TTO: 2006 (11 years); ATTO: 2007 (10 years); NTTO: 2005 (12 years). The mean age of NTTOs was therefore greater than ATTOs; however, the mean age for each group was very similar.

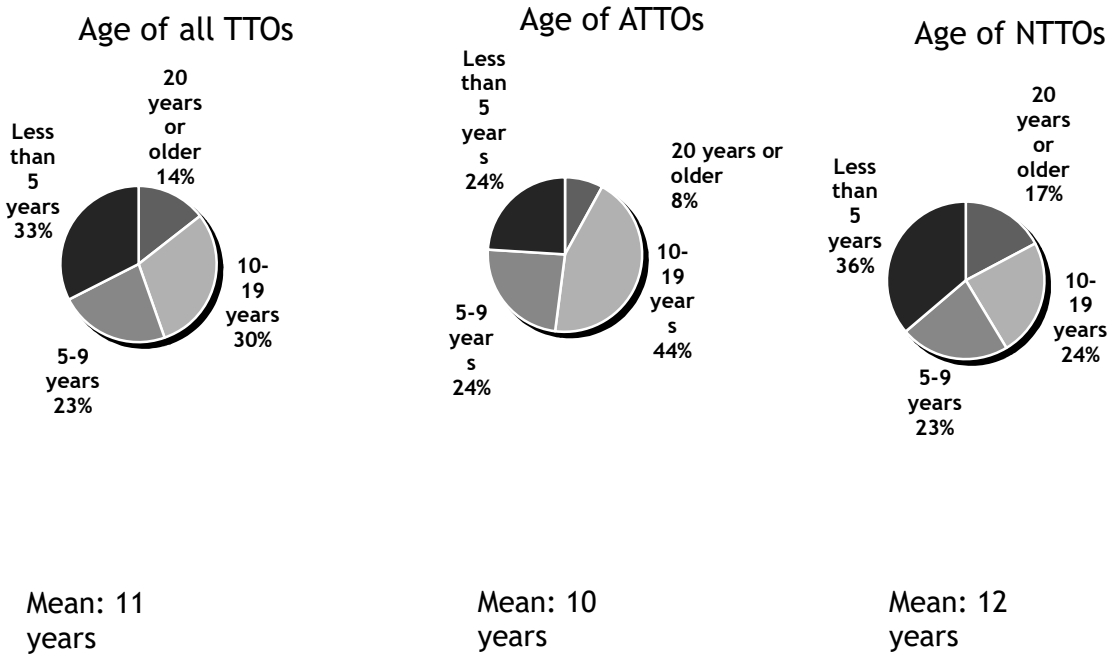

Figure 1: Age (years in operation) by TTO group

1.2 Technology transfer services provided by TTOs

The vast majority of TTOs (83 or 97.5%) perform some technology transfer services, as described in the questionnaire - the 2 organizations that do not are CCG/ZGDV and AVEPARK (spinpark), both in the NTTO group. Regarding IP (including IP licensing) only 61 organizations (72%) claim to perform some services in this category. The other 24 organizations are characterized by a focus on 'innovation park' or 'business park' type activities, or support of spin out companies (but

excluding any IP support). 22 of these organizations are within the NTTO group. The two organizations within the ATTO group are Audax ISCTE and Universidade de Aveiro (UATEC).

According to this data, as gathered from the survey, only 72% of Portugal's TTO infrastructures are capable of supporting IP licensing, which is one of the most recognized benchmarks of performance in technology transfer. For the ATTO group this figure is 92% and within the NTTO group IP competency extends to 63% of the offices that responded to the survey.

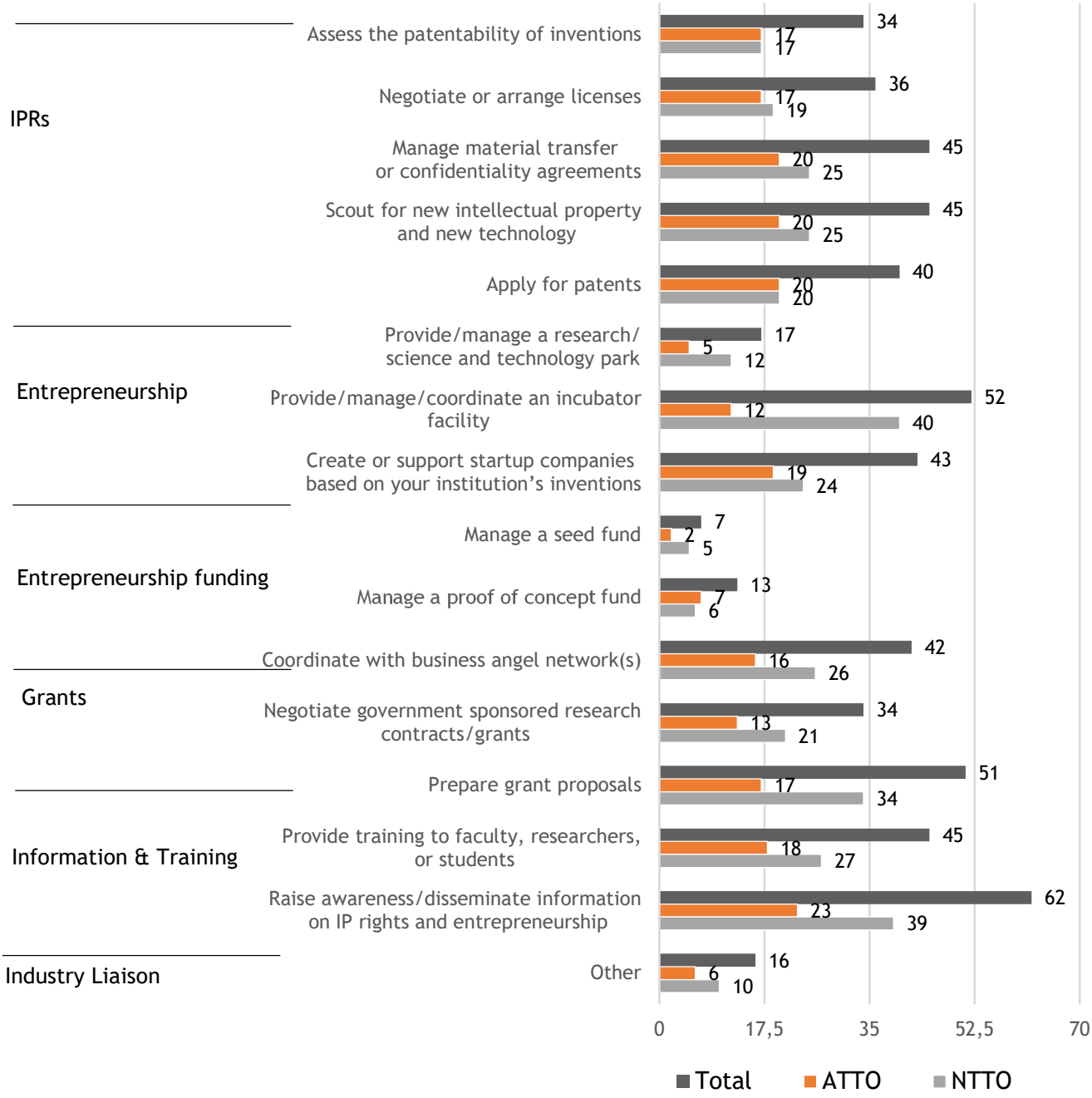

Figure 2. Technology transfer services provided by ATTOs [1]

[1] 1 of the NTTOs did not provide meaningful date for this survey question.

1.3. Number and main functions of TTO staff

The mean size of all the TTOs that responded to the survey is 9.5 FTE, with the mean for ATTOs being 5.5 FTE and for NTTOs 11 FTE. There appear to be some variations in the relative proportion of staff functions between the two years surveyed, with more staff allocated to 'Fundraising and coordination' in 2016 compared with 2015. The largest proportion of FTE was allocated to 'Other' functions in the survey in both 2015 and 2016; however, only 9 organizations of the 85 specified what 'other' referred to (this included 'administration', 'project management', 'communication and marketing', 'managing contract research' and 'legal support') therefore this category is very non-specific. Of the specific functions that have been described, 'Industrial liaison', 'Entrepreneurship/spinoff', 'Grants', and 'Licensing' account for a roughly equivalent effort from all TTOs, and in combination this is 51% and 50% of the FTE in 2015 and 2016, respectively. Efforts for 'Fundraising' and 'IP' are significantly lower than the other four specific functions described above. However, the effort applied to IP in the ATTO group is much greater than it is in the NTTO group (16% compared with 3% in both years). The other main difference between these two groups in both 2015 and 2016 is that 'Entrepreneurship/spinoff' uses much more staff time in the ATTO group (24%, 23%) than in the NTTO group (10%, 13%).

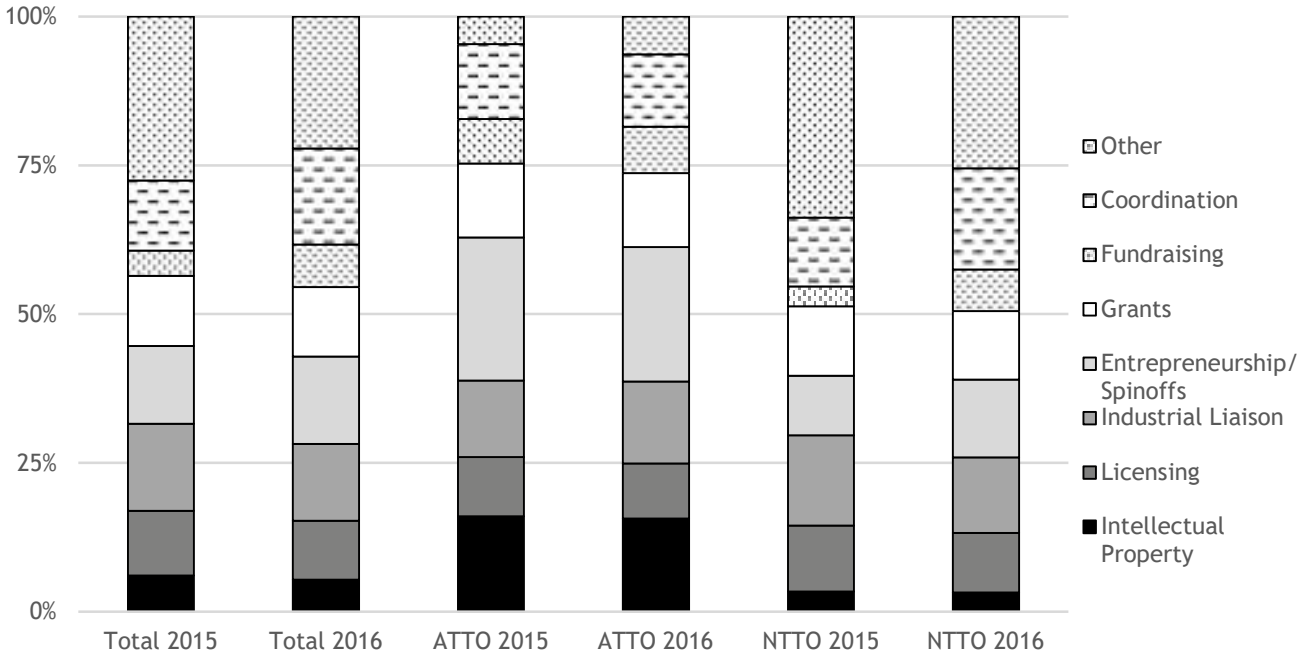

Figure 3: Main functions of Technical/professional staff (in FTE) 2015 and 2016 [2]

[2] The data analysis in the previous (2018) report has included data that is inconsistent with the raw data, as verified in the preparation of this report, for this reason the ATTO values in the current report do not correspond with the equivalent values in the previous report.

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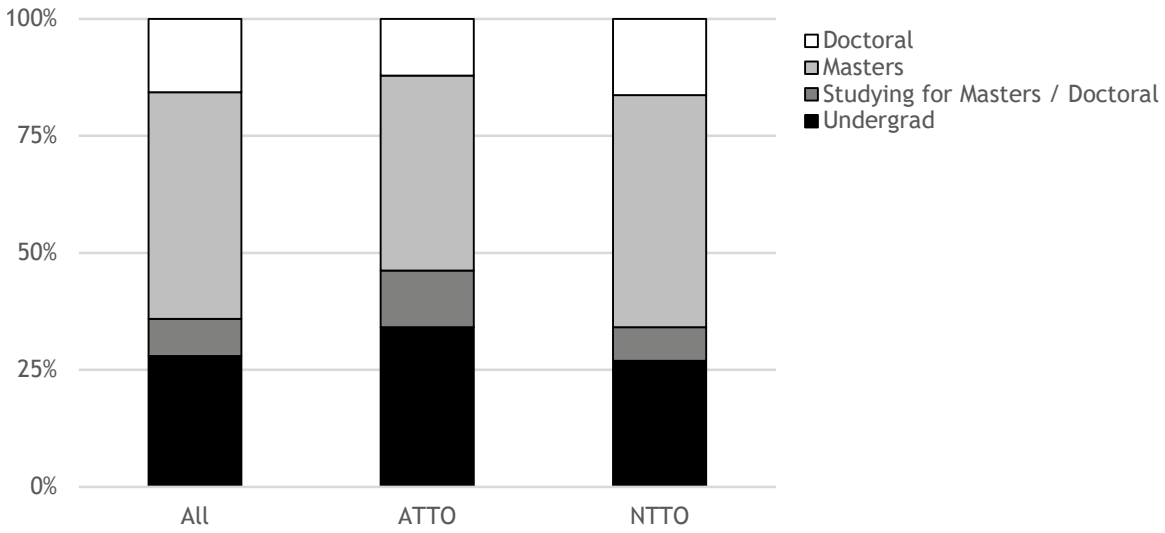
1.4. Human capital of technical/professional staff 3

The technical/professional staff of academic TTOs have relatively high levels of formal education, with 64% possessing a master or a PhD degree. The staff in the NTTO group present a higher share of staff with top formal education than staff in the ATTO group - 66% compared with 54% – see Figure 4.

In terms of type, the qualifications of the staff employed in all Portuguese TTOs is skewed towards 'Engineering or Natural Sciences' , accounting for 69%; however this specialization is less pronounced in the ATTO group with only half that percentage (34%) and the other disciplines are more evenly represented, also in this ATTO group 'Management' qualifications (including Business Administration, Economics, Management or Finance) are much more common (28%). Moreover, the category 'Others' includes mainly staff graduated in humanities and communication.

The data for the experience and training elements of the Survey are consistent with the position of technology transfer being a relatively new and unknown sector for its employees, and also that there is a significant turnover in employees, that requires a relatively large intake of new employees on a regular basis. As the TTO sector matures it would be expected that the experience of its workforce will increase, if experienced staff can be retained.

Figure 4: Technical/professional staff by formal education, 2016



[3] No meaningful data was provided by 2 of the NTTOs and 1 ATTO for the question on formal education and 2 of the NTTOs for the question on the area of their studies, therefore they were excluded from the analysis shown in Figure 4 and 5, respectively. For the question on industrial experience, no meaningful data was provided by 16 of the NTTOs and 4 ATTO, therefore they were excluded from the analysis shown in Figure 6. No meaningful data was provided by 2 of the NTTOs, therefore they were excluded from the analysis shown in Figure 7.

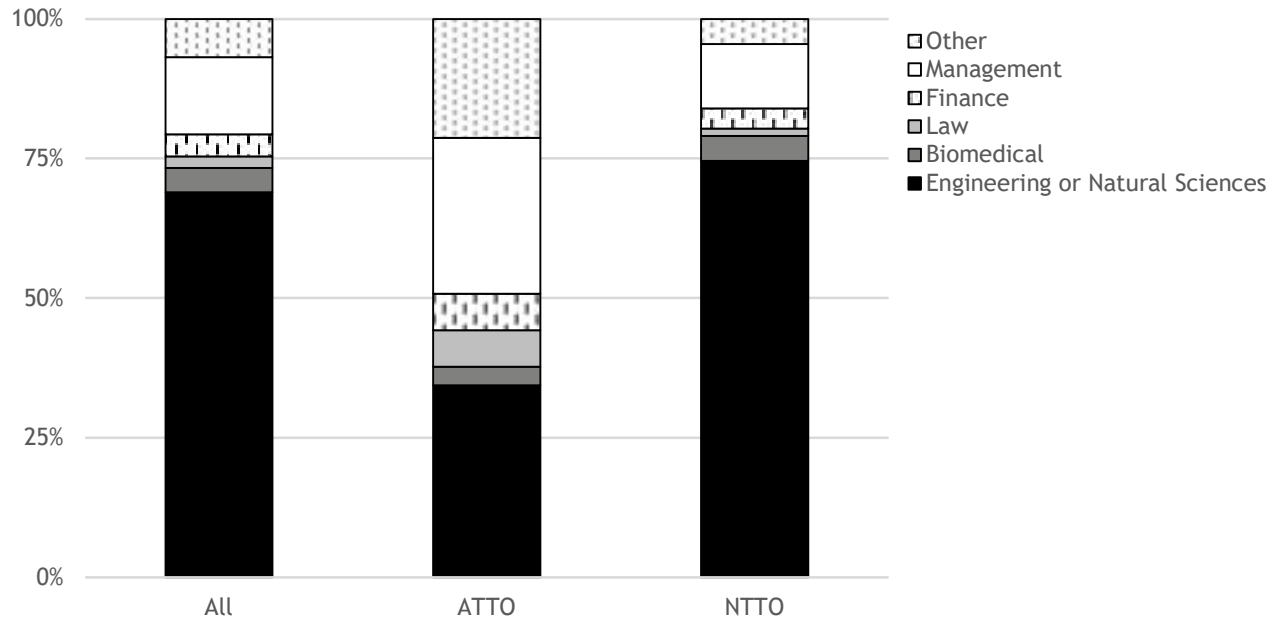


Figure 5: Technical/professional staff by type of formal education, 2016

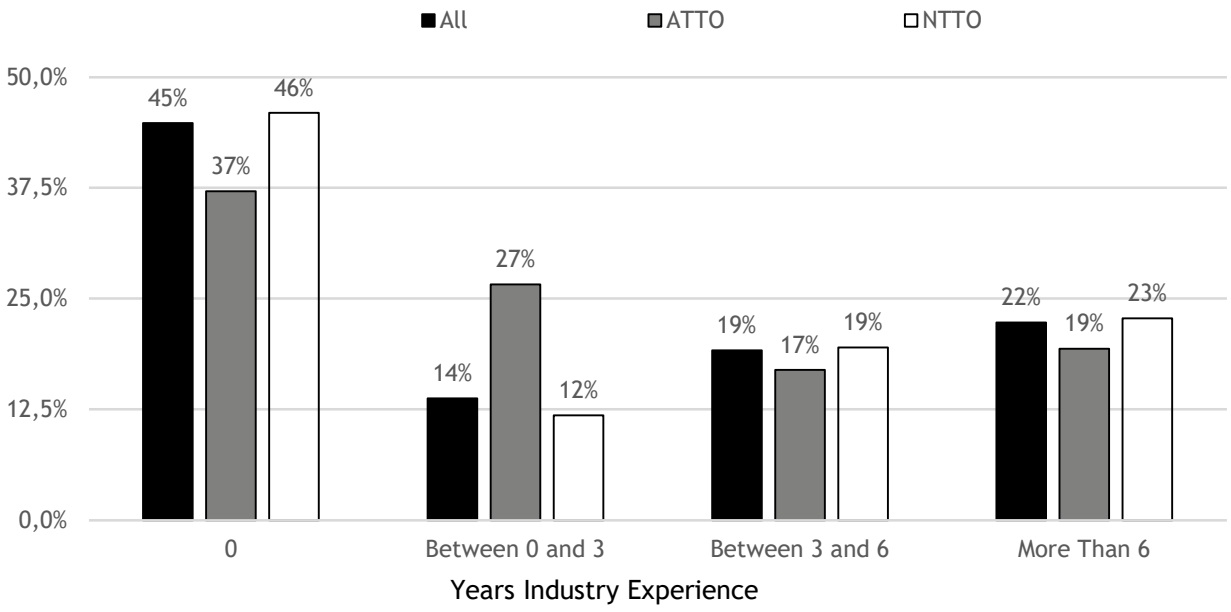


Figure 6: Industrial experience (in years) of technical/professional staff

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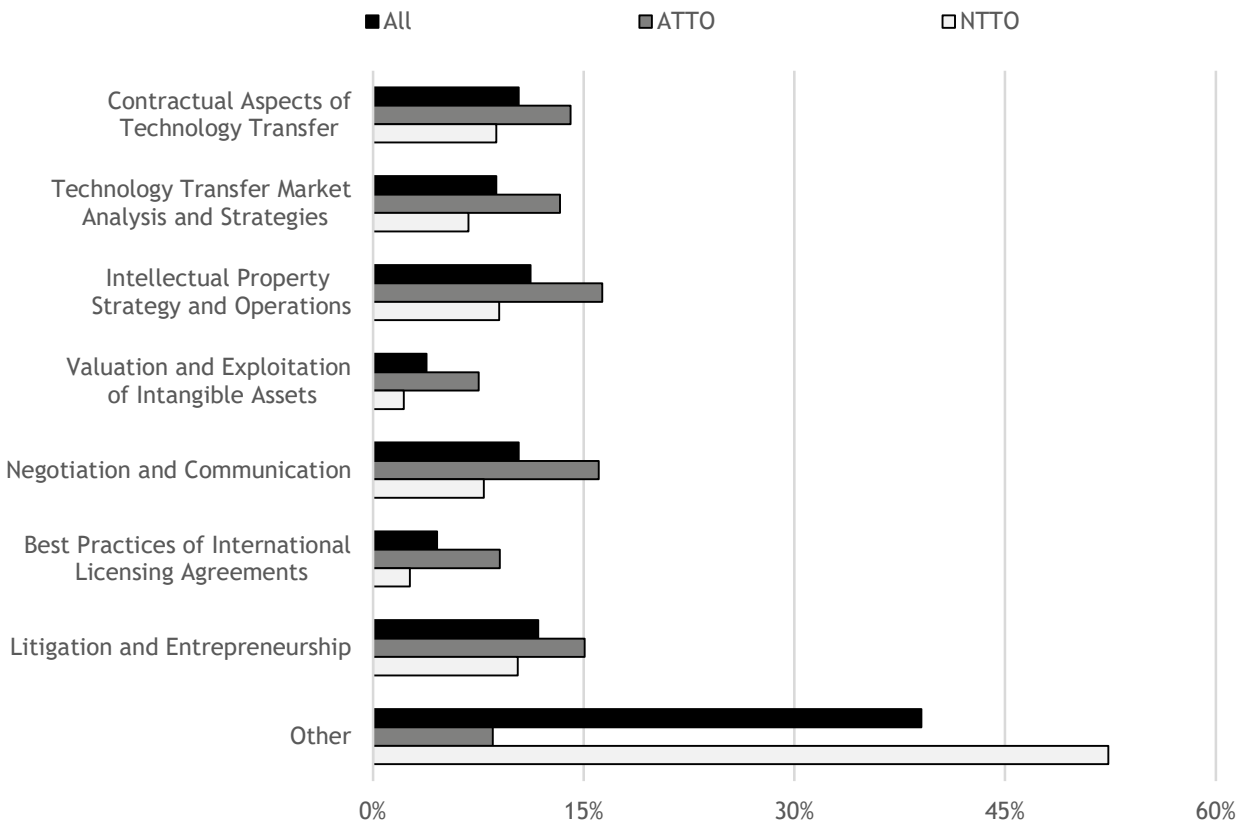

Figure 7: Type of training received by technical/professional staff, in 2014-201617

Chapter: 2 TTO Budget Information

2.1. Average real total expenditures of Portuguese TTOs[4]

In real terms (at constant 2011 Euro), the mean total expenditures of all TTOs amounted to 1.1 million euros in 2015 and 1.03 million euros in 2016, that is a 6.52% decline (see Figure 8a). The average size of the budgets for the NTTO groups was some 9.5 times greater than that of the ATTOs. This suggests a question of whether the NTTOs are performing additional functions compared with ATTO, or if the existence of funds for programmes such as 'proof of concept' or 'spin outs' is increasing the mean NTTO budget, but not similarly affecting FTE. The changes to the budgets between 2015 and 2016 were quite distinct when we compared ATTOs with NTTOs. The NTTOs registered an average real decline in the budget of 7% whereas ATTOs budgets experienced a modest increase of 3.6%, albeit from a much lower baseline.

Considering the budget median instead the mean, for all TTOs there was a decline of 18.8% from 2015 to 2016, with NTTOs budgets medians falling by 13.8% but the budget medians for the ATTOs increasing by 3.8% (see Figure 8b).

Taking into account the size of the TTOs, the data shows that the NTTO group had a much greater mean expenditure per collaborator than the ATTOs, this was found to be a factor of 6.2.for 2015 and 4.3 in 2016; however, the medians were almost identical in 2016. This data suggests that some NTTOs command much higher budgets and that these TTOs use their budgets in a different way from the majority of the NTTOs and the ATTOs. It also suggests that staff salaries plus salary overhead are only a minor factor in the budget for NTTO.

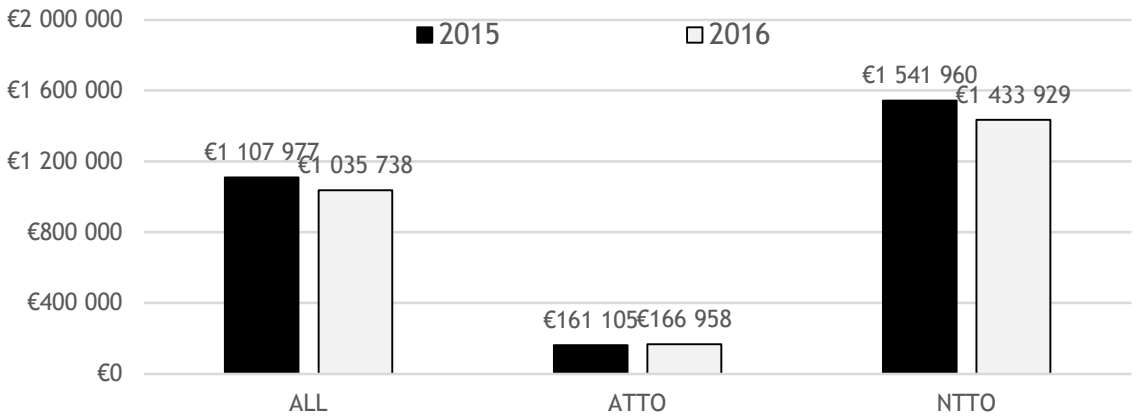

Figure 8a: TTOs' mean total expenditure (in euros, at constant prices of 2011)

[4] 15 out the 85 TTOs did not respond to this question (3 ATTO and 12 NTTO) and were excluded from the analysis.

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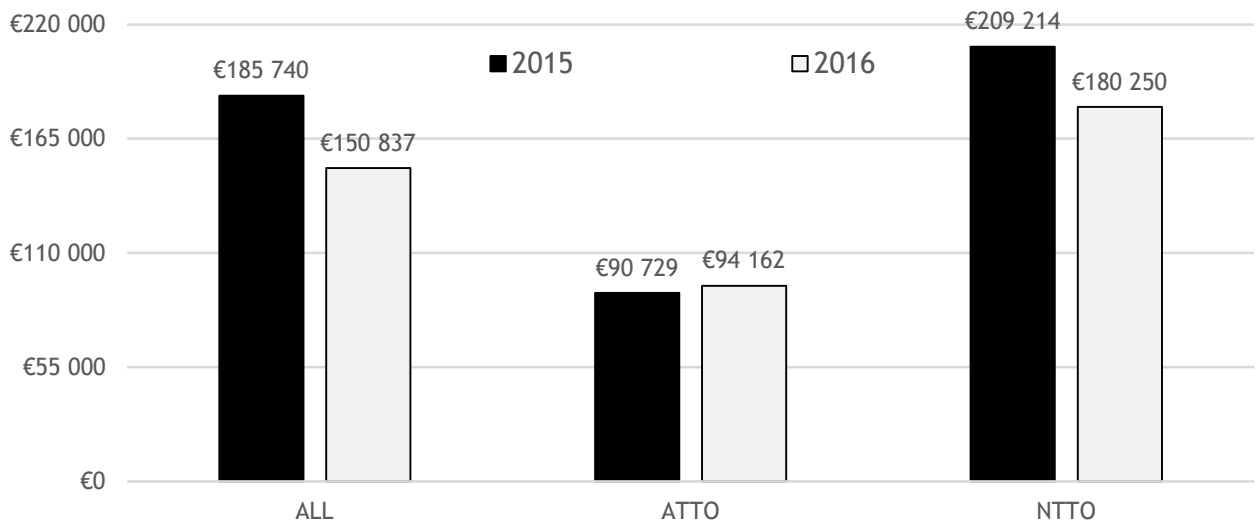

Figure 8b: TTOs' median total expenditure (in euros, at constant prices of 2011)p

The top budget of €45M was reported by ISQ - Instituto de Soldadura e Qualidade; however, it is not clear that this budget relates solely to TTO activities and may therefore be an outlier in the dataset. The 6 biggest remaining TTOs had budgets greater of €1M - €6M, with the highest being Uninova-Instituto para o desenvolvimento de novas tecnologias, with a budget of €5.7M (average 2015 and 2016).

Between 2015 and 2016, the real total expenditures per collaborator decreased on average (in the median) by 24.19% (34.14%) between 2015 and 2016.; Again, NTTOs registered a fall in their budget, about 28% (33.46%), while expenditure for ATTOs increased by 3.4% (3.8%) – see Table 2.

Table 2: TTOs' average and median total expenditure per collaborator (constant 2011 Euro)

		All TTOs	ATTO	NTTO
Mean	2015	€144,206.87	€28,768.82	€180,346.22
	2016	€109,370.48	€29,813.99	€129,532.91
	Percentage Change	-24.19	3.36	-28.18
Median	2015	€24,184.83	€16,201.63	€24,469.49
	2016	€15,927.85	€16,814.59	€16,282.77
	Percentage Change	-34.14	3.78	-33.46

2.2 Total budget by type of expenditure[5]

The spending of the TTOs in 2015 and 2016, according to the type of expenditure, is represented in Figures 9 (a) and 9 (b), respectively. The bulk of the expenditures in both 2015 and 2016 for All TTOs is accounted for by 'Human Resources' (57-59%), with ATTOs on average spending a larger share on this category (67-68%) than the NTTOs (52-56%). The remaining identified expenditure is on Patenting and Raising awareness of IPR and Entrepreneurship both around 7%. The ATTOs spend on average around twice as much as the NTTOs on these other two categories as a percentage of their expenditure. A large percentage of expenditure is described as 'other' (27-29%), but this is much smaller (x 3) for the ATTOs than the NTTOs.

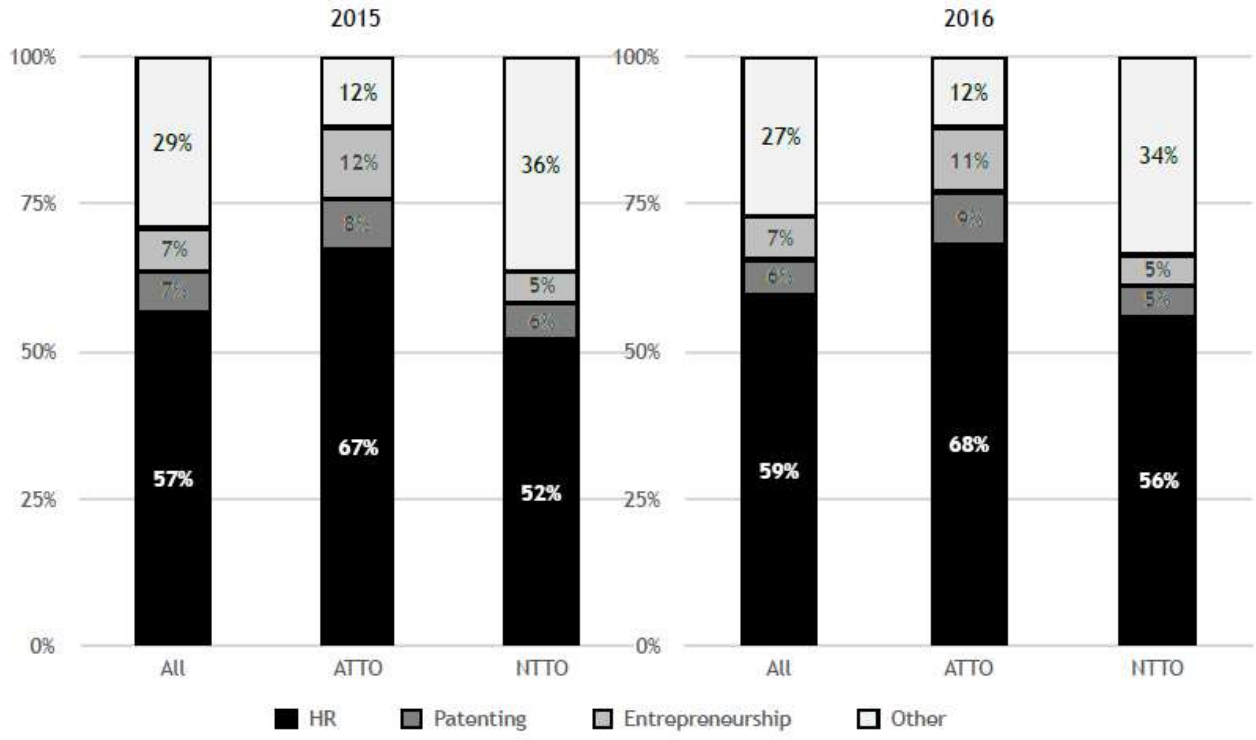

Figure 9: TTOs total expenditure by type (in percentage

[5] No meaningful data was provided by 16 of the NTTOs and 6 ATTOs, therefore they were excluded from the analysis shown in Figures 9 (a) and (b). The figures provided in the survey were converted to percentages, where necessary, and where less than 100% was indicated (cumulatively) by the TTOs in their responses, the shortfall was assumed to occur in the 'other' category.

2.3. Total revenues by source

Considering the data for All TTOs, the biggest source of revenues in both 2015 and 2016 originated from the TTOs' 'parent' Institution (see Figures 10a and 10b, respectively); however, the relative share was almost twice as much for ATTOs (47-48%) than for NTTOs (26-28%). The next biggest share came from 'External Services and Fees Supplied by Companies' (21-22%) and 'National Co-funded Projects (21-22%), with the share of revenues from External Services and Fees being much lower in ATTOs than NTTOs.

The next biggest share of revenues comes from 'International co-funded Projects' at 7-8% (and much higher for ATTOs than NTTOs), while the other categories account for a very small share of revenues, including 'License and Option Agreements'.

Overall, it is clear that on average all TTOs require support from a 'parent' organization in order to function, but revenue from providing services accounts for a significant share of revenues (and much more so for the NTTOs). The other feature to note in this data is that, on average, income from licences is very small and an insignificant share of total revenues.

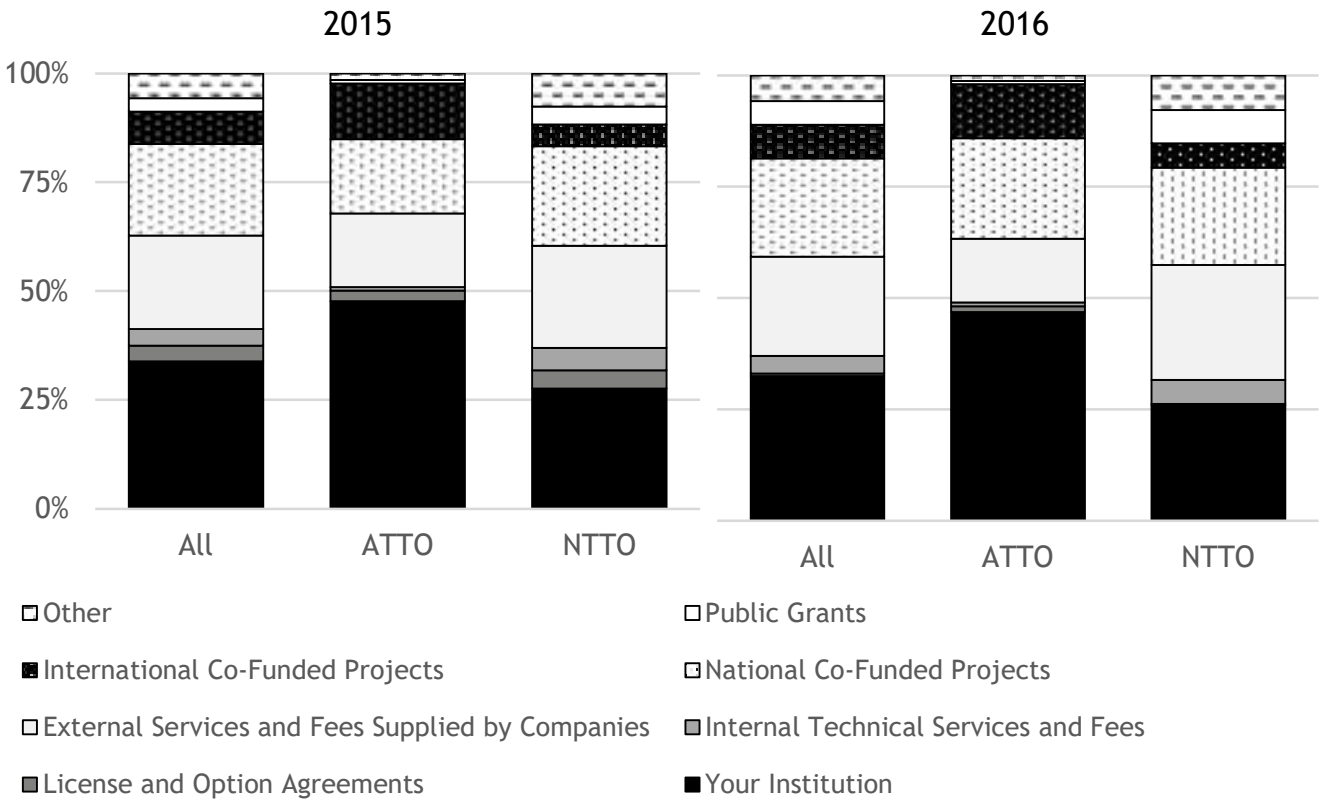

Figure 10: TTOs total revenues by source (as a percentage), 2015 and 2016 [6]

[6] No meaningful data was provided by 18 of the NTTOs and 5 ATTOs, therefore they were excluded from the analysis shown in Figures 10 (a) and (b). The figures provided in the survey were converted to percentages and where less than 100% was indicated by the TTOs in their responses, the shortfall was assumed to occur in the 'other' category.

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Chapter 3: The industry focus of TTOs

3.1 The main thematic industry focus of TTOs

The survey requested TTOs to indicate up to 3 themes from a list that represented the industrial focus of their office's activity, or to indicate that they did not have a focus. Some TTOs indicated more than 3 themes. The survey results are shown in graphically in Figure 11, the graph shows the percentage of the TTOs that selected each theme.

The most prevalent industry focus was Information & Communication Technologies, with 42 (49%) of all TTOs specifying this area. This was the most prevalent focus for both the ATTO and NTTO groups.

The top 5 areas for All TTOs also included 'Agro-food and Agro-processing', 'Health & Life Sciences', 'Renewable Energy' and 'Biotechnology'. This was also the top 5 for the ATTO group; however, the top 5 for the NTTO group was 'Information & Communication Technologies', 'Agro-food and Agro-processing', 'Health & Life Sciences', 'Advanced Production Systems' and 'Renewable Energy'. Therefore, there is an apparent difference in the main industry focus between the ATTOs and NTTOs; however, the difference appears to be relatively minor.

Nine (9) of the TTOs (11%) have specified a single industry focus, and an additional 44 (52%) have specified 2-3 areas. 19 TTOs (22%) have specified 4 or more areas and therefore have a looser thematic industry focus, while 13 TTOs (15%) state that they do not have a main thematic industry focus. When we consider the differences in the narrowness of focus between ATTOs and the NTTOs on a 'per organization' basis, The NTTOs showed much narrower focus (75% with 3 or fewer specializations) than the ATTOs (32%). This suggests that the NTTOs are typically more aligned to a particular industry theme than the ATTOs. This finding is expected since the ATTOs would be expected to support all the technology transfer needs of a University or Polytechnic institution which would typically have a very diverse portfolio or research, and would work with a broad range of industries.

Table 3: Specializations of industry sector ('focus') by organization.

	High Focus (%)	Low Focus (%)	No Focus (%)
All TTO	62	22	15
ATTO	32	44	24
NTTO	75	13	12

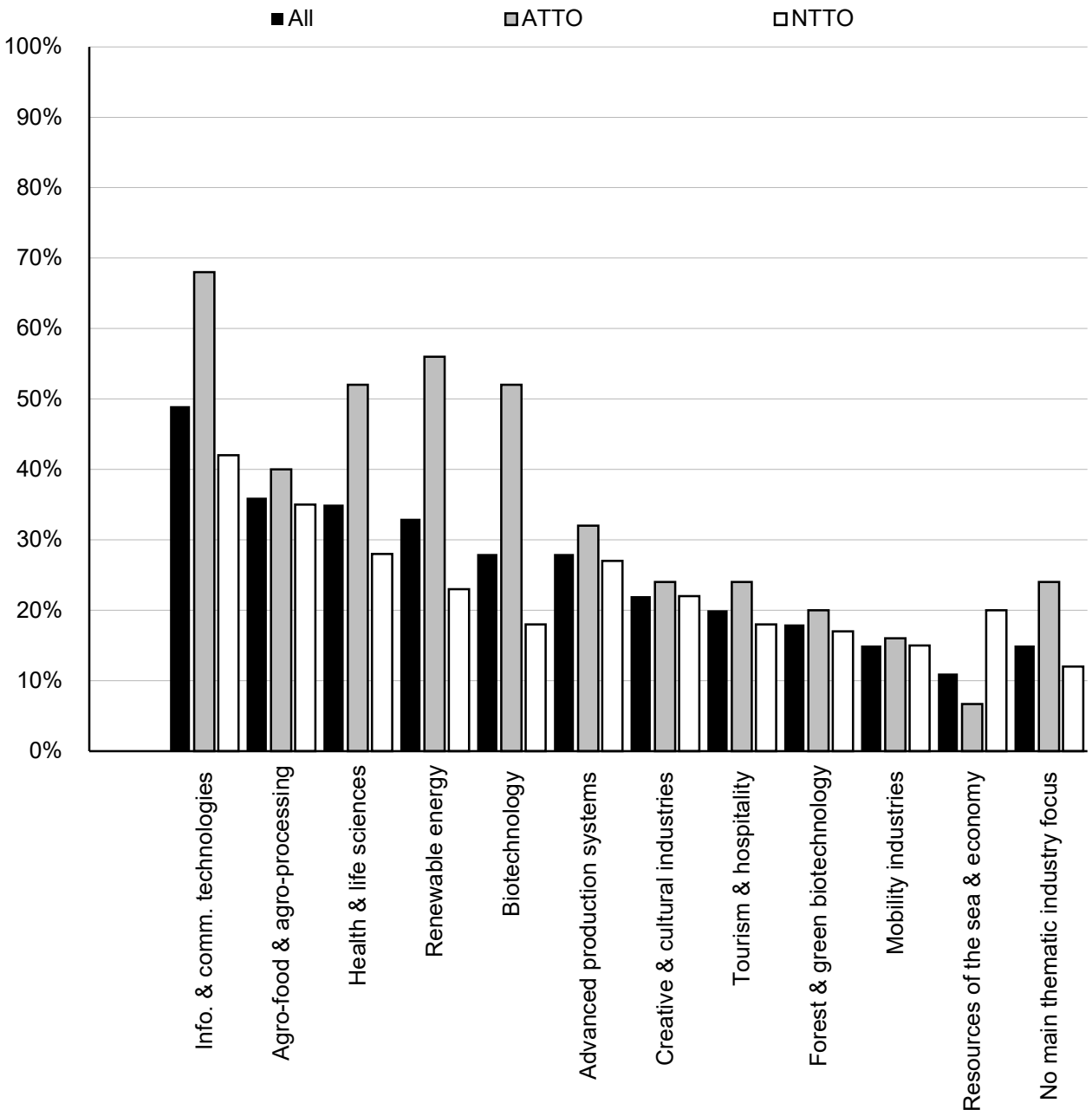


Figure 11: Main thematic industry focus of Portuguese TTOs

Chapter 4. Intellectual Property rights

4.1 Percentage of all institutional patent applications handled by TTOs

Overall, less than half the TTOs (41%) handle patent applications themselves; however, the proportion is quite different when comparing the ATTO and NTTO groups. On average 72% of ATTOs handle their organization's patent applications (average values for 2015 and 2016), while this number drops to 24%, in the case of the NTTOs (see Figure 12).

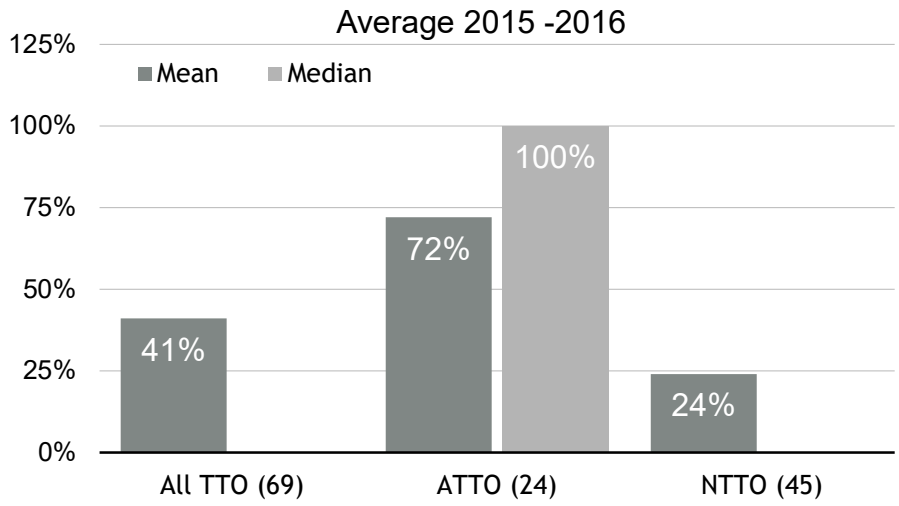
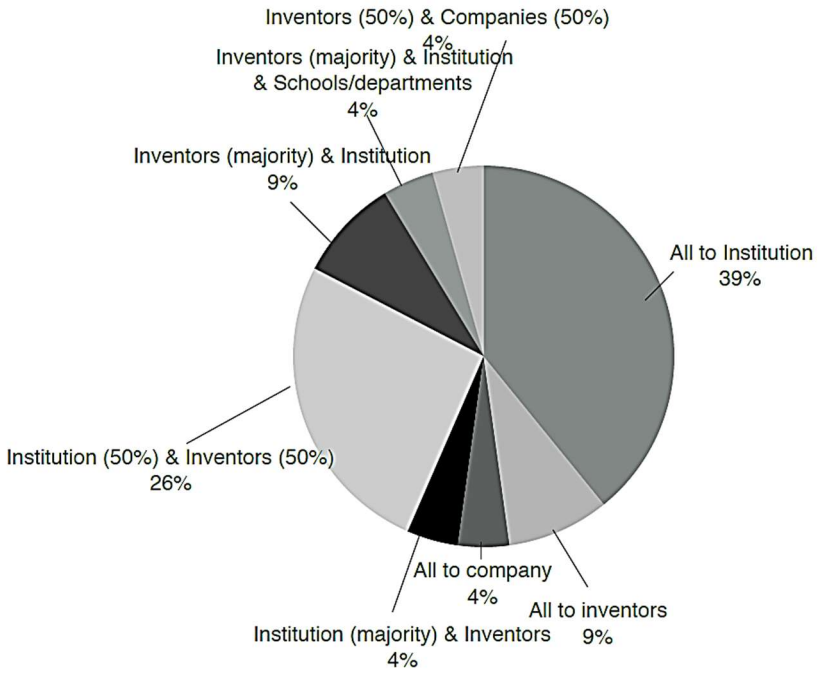


Figure 12: Percentage (mean and median) of patent applications handled by TTOs

4.2 Distribution of royalties from intellectual property, 2015-2016

In the years that were reported in the survey (2015, 2016) a total of 23 organizations received royalties (27%); 12 of these were from the ATTO group (14%of all TTOs and 48% of ATTOs) and the remaining 11 from the NTTO group (13% of all TTOs and 18% of NTTOs) - see Figure 13. This data indicates that the frequency of IP deals which provide royalties is relatively low, and that these deals are more likely to be achieved by ATTOs than NTTOs. The royalty distribution mechanisms used by Portuguese TTOs are very diverse and there were at least eight different models noted in the responses to the survey. The most common of these mechanisms was for the institution to retain all the royalties (39% of all TTOs),

however it is clear that there is no consensus model that Portuguese TTOs apply to the



distribution of royalty income.

Figure 13: Distribution of the royalties from intellectual property, 2015 - 2016

When the mechanisms for distributing royalties were compared between the ATTO group and the NTTO group, the most obvious difference was that the ATTOs most common mechanism was to distribute royalties equally between the institution and the inventor (42% of ATTOs) while the most common mechanism for NTTOs was for the Institution to retain all the royalties (82% of NTTOs).

4.3 New patent applications filed by TTOs for their institutions[7]

The data provided by TTOs showed that on average TTOs made 6.2 new patent applications (priority filings) per office in 2015 and 5.6 in 2016 (see Figure 14). The ATTO group was entirely responsible for the new patent filings in 2015 and accounted for the vast majority of filings in 2016. There was a slight reduction in the average number of patent filings been 2015 and 2016.

The largest share of new patent applications was made as provisional patent filings, which is designed to provide a lower-cost first patent filing, followed by full filings at the

[7] Note. Of the 85 TTOs included in this analysis, 14 did not provide data relevant to new patent applications (one from the ATTO group and 13 from the NTTO Group), and these TTOs were excluded from the analysis.

Portuguese Patent Office. The remaining patent filing types were less frequent in both years for all TTOs apart from Patent co-operation treaty (PCT) filings in the NTTO group in 2016.

This variation should be put in the context of total annual number of patent filing by the NTTO group with is only around 25% of annual filings for all TTOs.

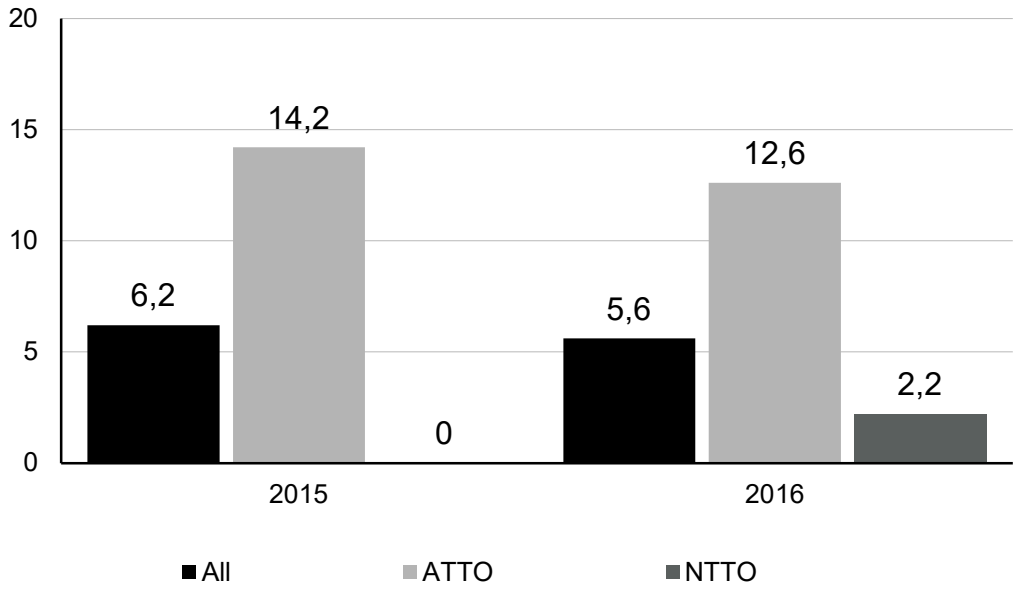


Figure 14: Average number of new patent applications by TTOs, 2015-2016

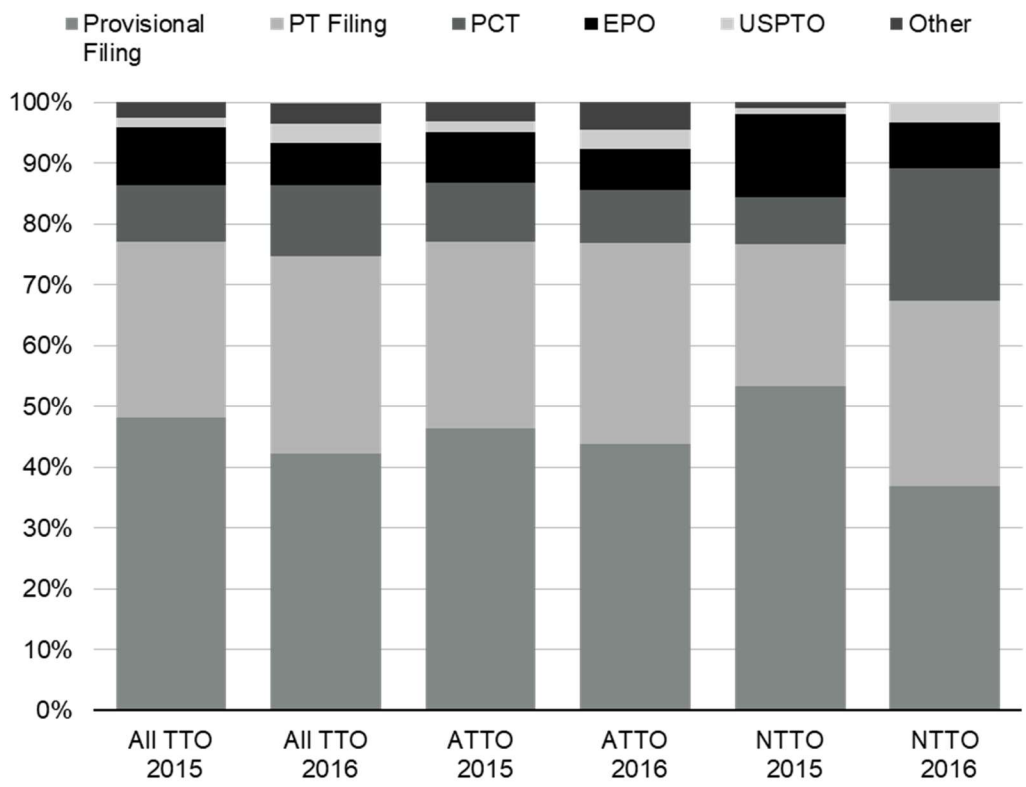


Figure 15: Distribution of new patent applications, 2015-2016

4.4 Patent application by subject areas

Of all the TTOs surveyed, only 46 (54%) provided an answer to this question, (21 ATTOs and 25 NTTOs). The most popular category for patent applications as reported by 27 out of the 46 TTOs (58%) was 'Biomedical' which includes diagnostics, medical devices, pharmaceuticals, etc. for human and animal health. The next biggest category was Nanotechnology and New Materials (46%), followed by Computers, Communication Equipment and Software (41%).

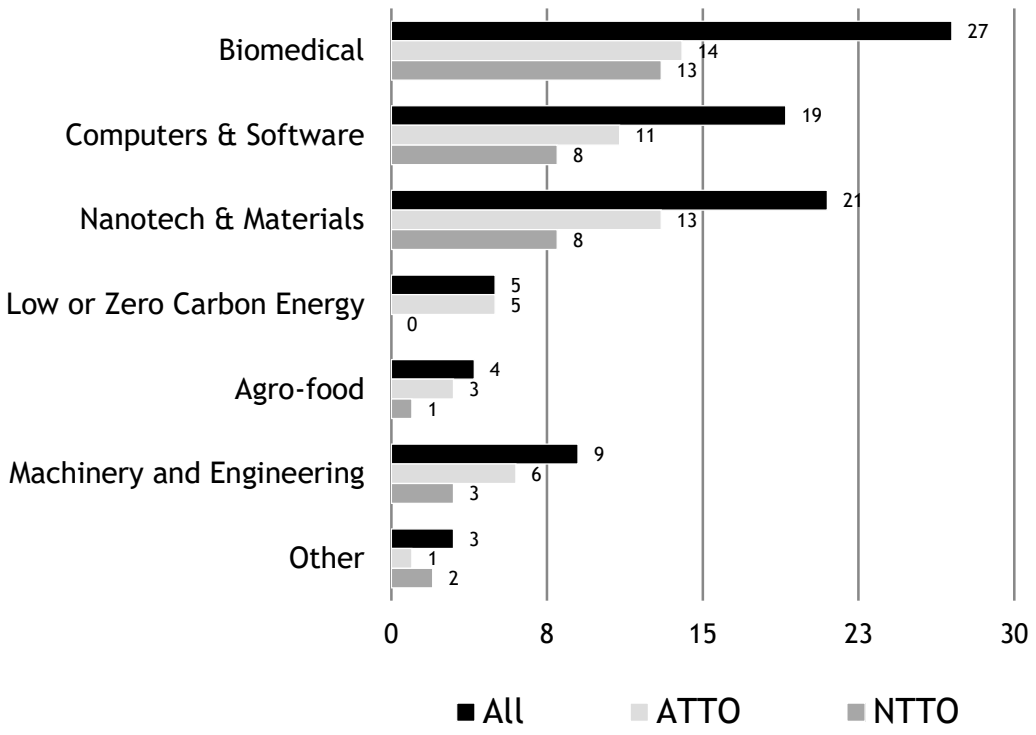
Less frequent subject areas for new patent applications were: Machinery/ Engineering / Systems /Consumer goods (20%), Low or Zero Carbon Energy (11%), and Agro-Food and Related (7%). The results are shown in Figure 16. This trend was broadly the same for ATTOs and NTTOs, although Nanotechnology and Materials was a more popular patent subject category with ATTOs than NTTOs. The original responses in the 'Other' category were subdivided into 3 subcategories based on common elements. These categories are the ones shown in Figure 16.

Figure 16: Patents applications by subject area in 2015 or 2016

4.5 Patents granted to the institution

The number of patents granted to All TTOs rose by 8% from 2015 to 2016, although there was a decline in ATTO grants and a rise in NTTO grants. Around 50% of all the patents were granted by the Portuguese patent office and around 25% by the EPO. The numbers of patents granted to ATTOs was around three times the number of those granted to the NTTOs. 14 TTOs did not provide data (2 ATTOs and 12 NTTOs).

Table 4 : Number (total) of patents granted to the institution



	All		Portuguese		EPO		USPTO		Other	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
All	89	96	51	44	26	21	6	10	6	21
ATTO	71	68	39	28	20	11	6	8	6	21
NTTO	18	28	12	16	6	10	0	2	0	0

4.6. Total number of active patents

Active patents were held by 37 of the 85 TTOs that participated in the survey (although 14 out of the 85 did not provide data in this category). The number of total active patents in All TTOs increased from 1324 to 1436 between 2015 and 2016. This was an increase of 10%. The increase was 10.1% in the case of university ATTOs (1025 to 1129) and 9.4% for NTTOs (299 to 325).

Of the 37 TTOs that held active patents, 19 were in the ATTO group and the remaining 18 were in the larger NTTO group. By numbers of patents (averaged for 2015-16), more than 50% of all active patents were held by only 3 organizations (3.5%) which were Universidade de Lisboa - Instituto Superior Técnico, Instituto de Telecomunicações and Universidade do Porto; 95% of all active patents were held by 18 organizations (21%) 12 of which were in the ATTO group and 6 were in the NTTO group.

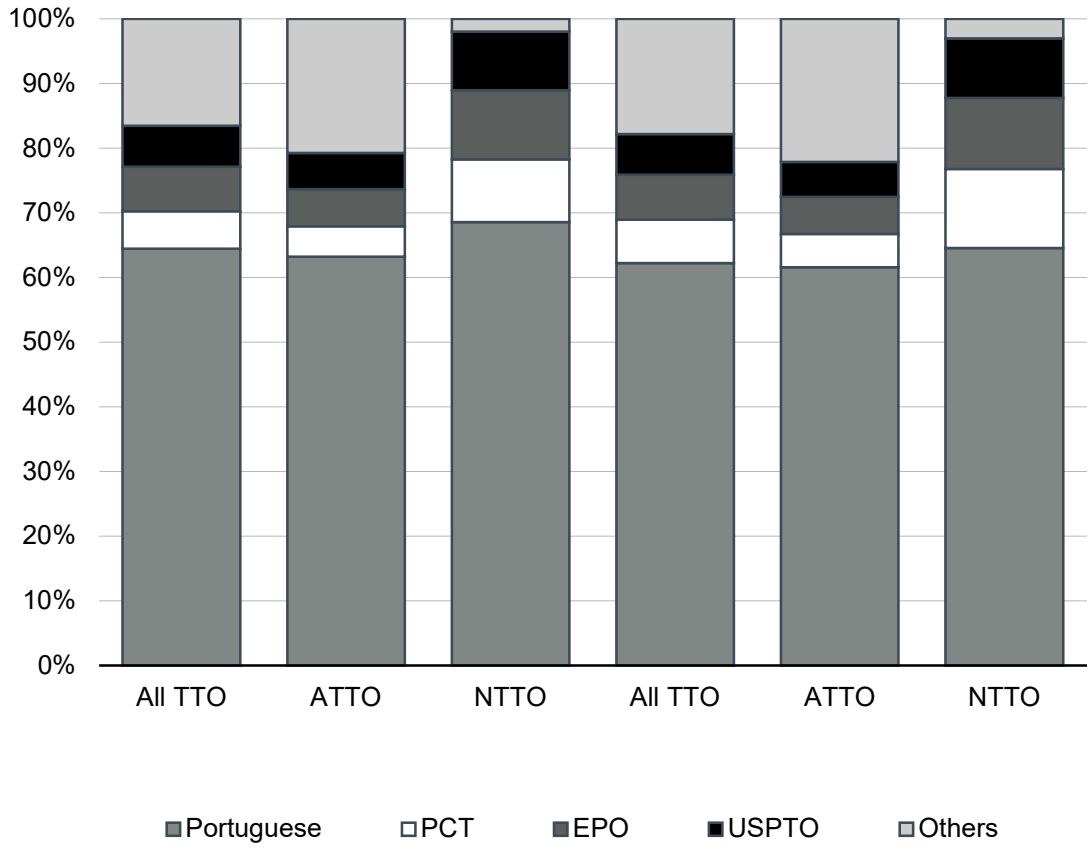


Figure 17: Total number of active patents in 2015 and 2016, by type of filing

The ATTO group that participated (n=24) was responsible for 77 % of all the active patents held by reporting TTOs (average of 2015-2016), 6 ATTOs reported no active patents (25%). The NTTO group that participated was larger in number (n=47) and held 23% of the active patents, and 28 of these organizations reported no active patents (60%).

Most of the active patents held at the end of 2015 and the end of 2016 by TTOs were granted by the Portuguese patent office (62% and 69%, respectively). Active foreign patents held by TTOs (excluding EPO and USPTO) is the next largest category (17-18%), however this was negligible for the NTTO group (2%-3%), whereas in the case of university TTOs it was 21%-22% of active patents. EPO patents are the next largest category for All TTOs, followed by PCT then USPTO.

This data indicates that less than half of the TTO patent portfolio is targeted towards international markets.

4.7 Non-patent IPR [8]

Overall, the TTOs which responded to this survey possessed 305 non-patent IP rights (IPRs) in 2016, which was an increase of 47 (18%) from the total of 258 in 2016. The IPRs are predominantly trademarks, which were 84% of the 2016 total, followed by design rights at 13%. The ATTO group are responsible for 73% of these IPRs. The number of copyrights is very small, apart from one University in the ATTO group (Universidade Nova de Lisboa - Faculdade de Ciências e Tecnologia, id no 231) that reported it had 8000 copyrights; however, this number was excluded from the analysis shown in figure 19 as it appears to be an estimate only which could not be verified, and its inclusion would create a large distortion in the data set. The TTOs reported only 'Utility Models' in the 'Other' IPR category, these are a simpler type of patent that is more limited in scope, territory and period of validity. It is clear that Utility Patents were not widely used in Portugal during the reporting period of the survey.

The average number of non-patent IPRs reported by TTOs was 3.69 per TTO in 2015 rising to 4.36 in 2016; however the distribution of these IPRs is heavily distorted with the top 6 TTOs (8.5%) in this category reporting 212 (70%) of the IPRs in 2016 (this analysis excludes the 8000 copyrights previously described).

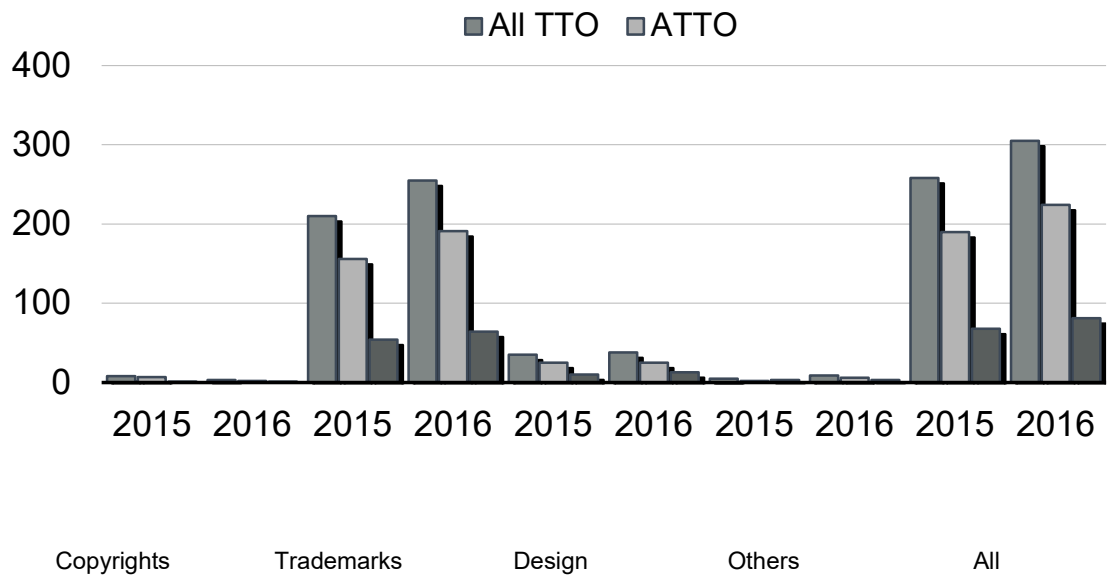


Figure 18: Total number of other types of IPR (non-patent), 2015 and 2016

[8] Note 14 TTOs did not provide data for this category in the survey (1 ATTO and 13 NTTOs). The TTOs responding to the 'other' category all specified 'Utility Models' which are a simpler type of patent that is more limited in scope, territory and period of validity.

Chapter 5. Commercialization of IPRs

5.1. IP Agreements that were executed by TTOs

The total number of IP Agreements, and specifically, licenses, option agreements, and assignments that were executed by the all the TTOs who provided data for this section of the survey (72) was 235 in 2015 and 266 in 2016. This is an average of 3.31 and 3.75 per office, respectively. The breakdown of these licensees by national origin of licensees in shown in Figure 19.

The most common type of licensee was a Portuguese partner, which accounted for 78% (2015) and 80% (2016) of all the licenses. Both ATTOs and NTTOs executed around the same number of licences with Portuguese partners. Most of the remaining licences were executed with EU partners (41 in 2015 and 34 in 2016), with the NTTOs being responsible for almost all these (35 and 29, respectively). As with patents, the distribution between the individual TTOs was very uneven, although the higher volume of licenses was not executed by the same TTOs that are leaders for patents. The questionnaire did not require respondents to state the type of IP that was the subject of the licence therefore it is possible that these licences are not focused on patented IP.

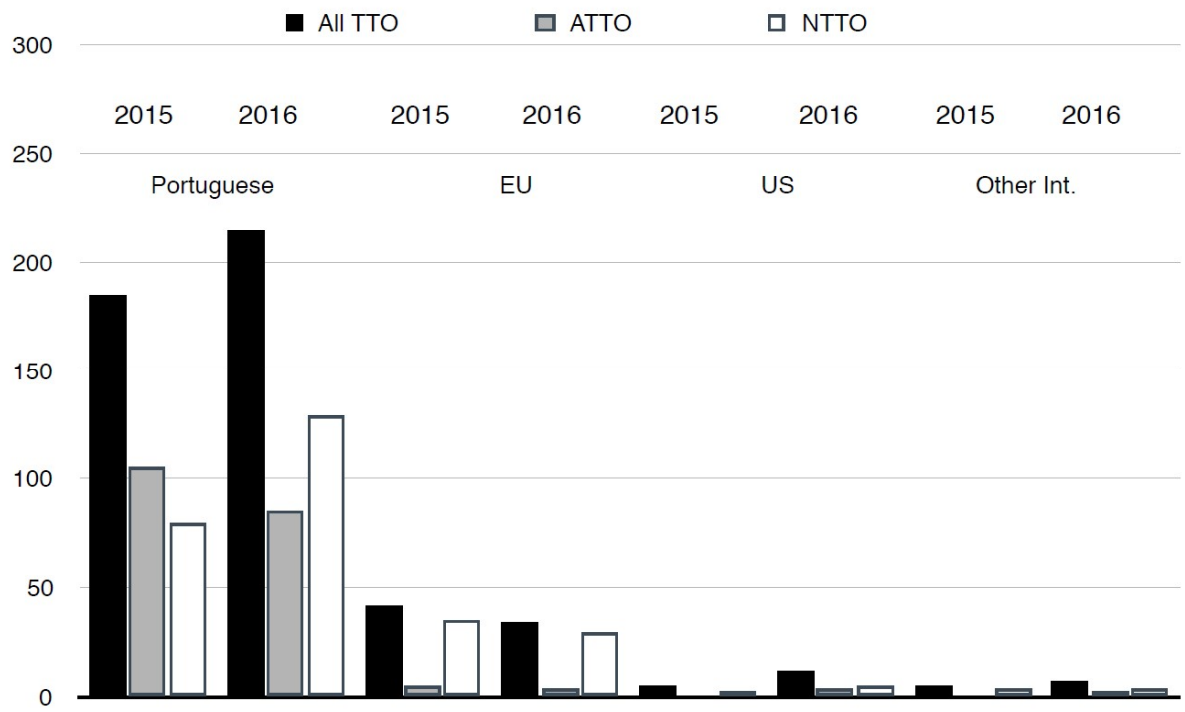


Figure 19: IP agreements that were executed by TTOs, by type of partner

5.2. IP agreements granted to companies

The total number of licences granted to companies by Portuguese TTOs was 165.5 (the average annual total for the survey inclusion period of 2015 and 2016). The majority of licenses were granted to companies that has less than 250 employees, but which were not 'Start-up' companies. Fewer licenses were granted to startup companies and the smallest number were granted to larger companies that have more than 250 employees (see Figure 20).

When comparing the patterns between the ATTOs and NTTOs, the NTTOs granted the largest share (78%) of these licences, with the biggest differences seen in the number of licences granted to non-startup companies which have fewer than 250 employees. Similar numbers of licences were granted to start-up companies by both groups and the NTTOs granted slightly more licenses to the larger companies than did the ATTOs.

The Top 5 TTOs in this category were responsible for more than 55% of the number of licences granted, indicating that there is an uneven distribution of licensing activity in the 85 TTOs that were surveyed.

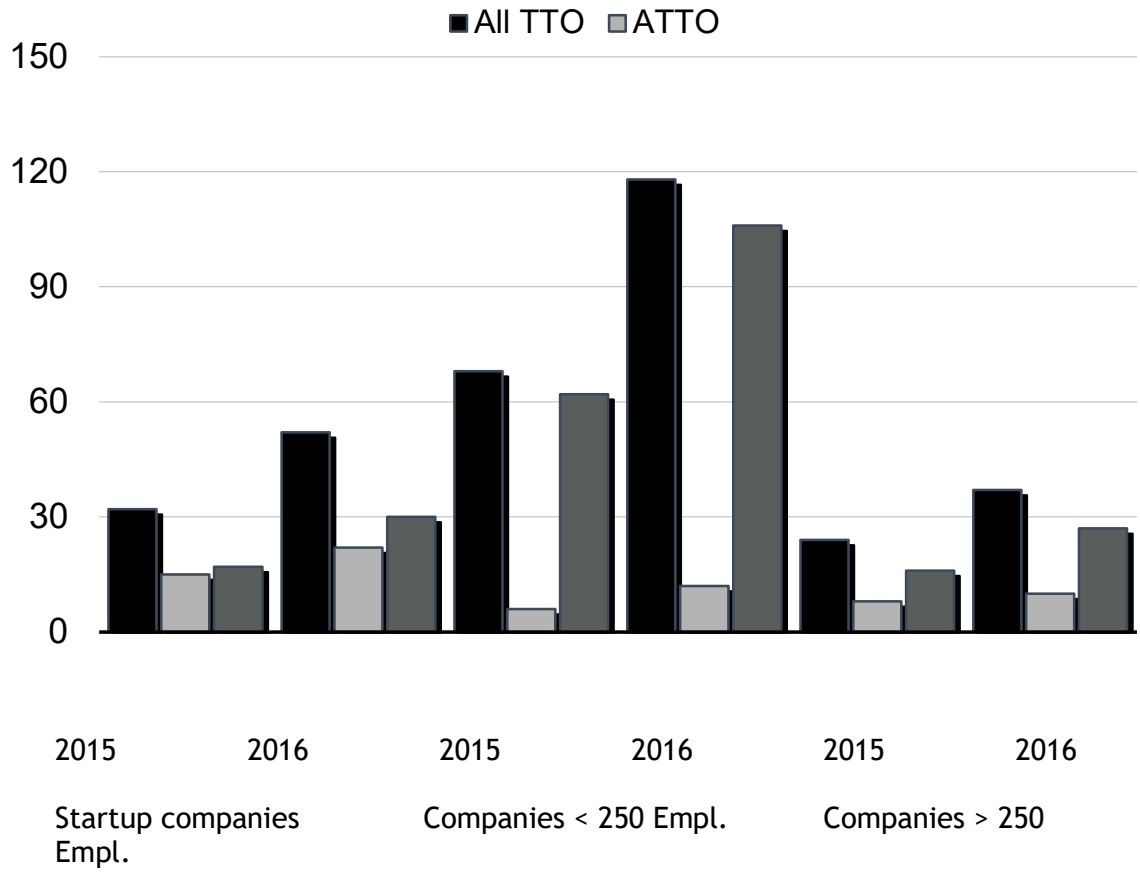


Figure 20: IP agreements granted (by company type)

5.3. Licence income [9]

The total license income from intellectual property for all the TTOs that provided data on License income was €1.595 Million in 2015 and €1.015 Million in 2016 (average of €1.305 Million) as shown in Figure 21. The income per TTO was €14,922 (2015) and €19,193 (2016). The total license income (average of 2015 and 2016) for the ATTOs was €351k and for the NTTOs was €954k. There is a large difference in the total licence income reported for 2015 and 2016, indicating that license income for TTOs may be highly variable from year-to-year.

Of the 68 TTOs that were included in this analysis, only 20 (29%) reported any licence income in either 2015 or 2016); these 20 TTOs were split approximately equally between the ATTO and NTTO groupings. International licences accounted for 24% of the licence income from these 20 TTOs (average for 2015 and 2016), and there was little variation between the NTTOs (25%) and the ATTOs (22%). When the TTOs were ranked according to license income, the top 5 TTOs generated 65% of all the licence income. The top 5 TTOs were:

1. i3S - Instituto de Investigaçãoo e Inovação em Saúde (NTTO)
2. INESC MN (NTTO)
3. Universidade de Minho (ATTO)
4. Universidade do Porto (ATTO)
5. Biocant (NTTO)

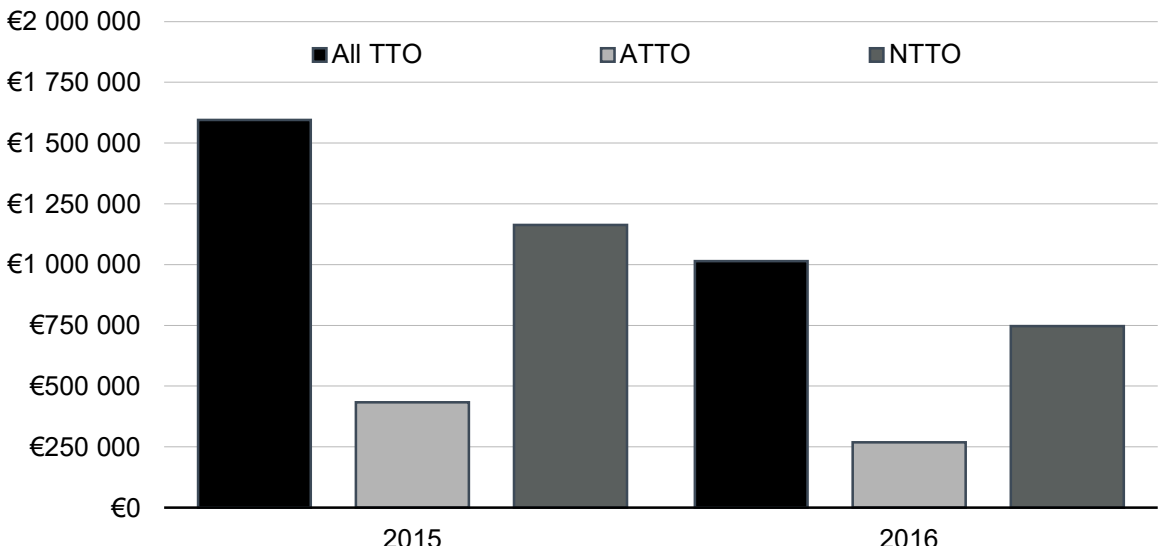


Figure 21: Licence income associated with TTOs (2011 Euro)

[9] Note: 17 TTOs (2 of which were ATTOs) did not provide data for this question, and they were excluded from this analysis. All amounts are shown in constant 2011 Euro.

5.4. R&D agreements between Institutions and companies [10]

The total number of research and development (R&D) agreements that were executed by all TTOs that participated in the survey, and that responded to this question, was 831 for 2015 and 914 for 2016; the average total number for these two years was 873. The number of R&D agreements executed by ATTOs was 389 and for NTTOs was 484 (these are the averages of both years). See Figure 22.

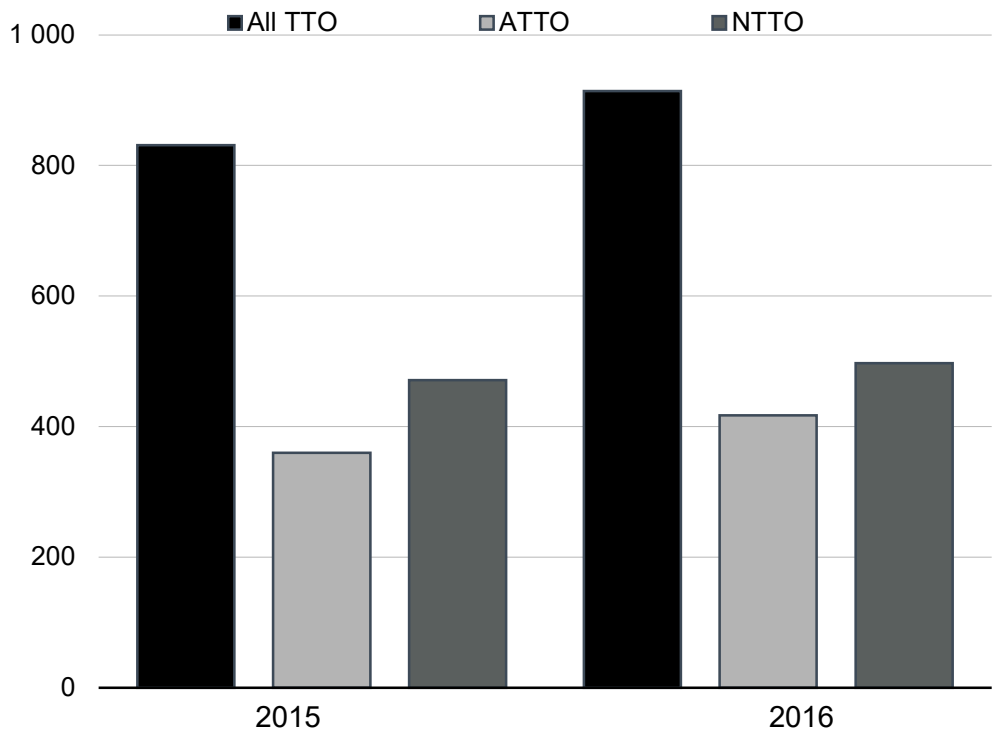


Figure 22: R&D agreements between the institution and companies, executed by TTOs

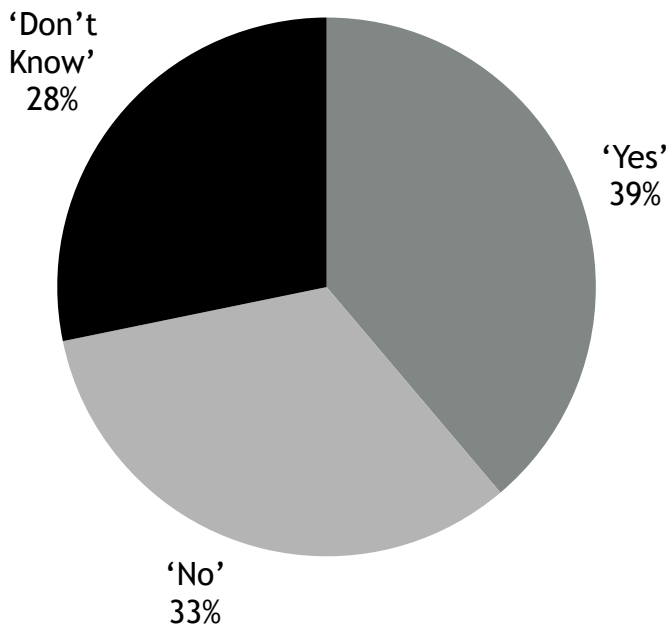
5.5. Commercially profitable products or processes from TTO Licencing.

All of the 85 TTO's included in this analysis provided a response the the question of whether or not their IP licences had resulted in profitable products in the years 2014-16; 39% responded 'Yes', 33% responded 'No' and 28% responded 'Don't Know'. The responses from the ATTOs were 68% 'Yes', 20% 'No' and 12% 'Don't Know'; the responses from the NTTOs were 27% 'Yes', 38% 'No' and 35% 'Don't Know'. See Figure 23.

[10] Note. 16 TTOs (2 of which were ATTOs) did not provide data for this question, and they were excluded from this analysis. Universidade Nova de Lisboa - Faculdade de Ciências e Tecnologia provided an approximate range in response to this question, therefore the midpoint of the range was assumed as the number of R&D agreements.

Of the 20 TTOs that reported licence income (see 5.3), 16 of them (80%) responded 'Yes' to the question, 3 (15%) responded 'No' and 1 (5%) responded 'Don't Know'. There is therefore some alignment between this group of 20 TTOs that are relatively successful in generating income from licencing, and the group of TTOs that reports that there are commercially profitable products that are linked to its licences.

Figure 23: Commercially profitable products or processes derived from TTO licencing



Chapter 6. Spin-Off and Start-Up Companies

6.1. Creation and continued existence of Spin-offs and Start-ups. [11]

'Spin-off' companies are those that are founded using the IP or other assets that are owned by a 'parent' organization - in this case, 'Spin-off' companies are those created by the TTOs or their institutional owners or stakeholders. 'Start-up' companies are simply newly stablished companies, and in this case they refer to companies that are founded by entrepreneurs that are employed by the institutional owners or stakeholders, but that are not owned by those institutions.

In 2015, 352 Spin-offs and Start-ups were established, and this number increased to 389 in 2016. Only 8% of the 2015 companies were created with equity owned by the institutions (7% in 2016). The figures provided by the TTOs in the survey do not precisely match the apparent turnover of the number of companies, i.e. the number of companies that were reported as active at the end of 2016 are more than the number at the end of 2015 plus the new 2016 companies and minus the companies that ceased operations in 2016. See Table 5.

Approximately one third of the new companies were reported by the ATTOs and two thirds by the NTTOs.

Table 5 : TTO 'spin-off' and 'start-up' companies in 2015 and 2016

	Newly Established		Created With Equity by the Institution		Ceased Operations		Active at End of Year	
	2015	2016	2015	2016	2015	2016	2015	2016
All	352	389	29	27	62	83	1265	1600
ATTO	110	110	15	8	15	11	382	439
NTTO	242	279	14	19	47	72	883	1161

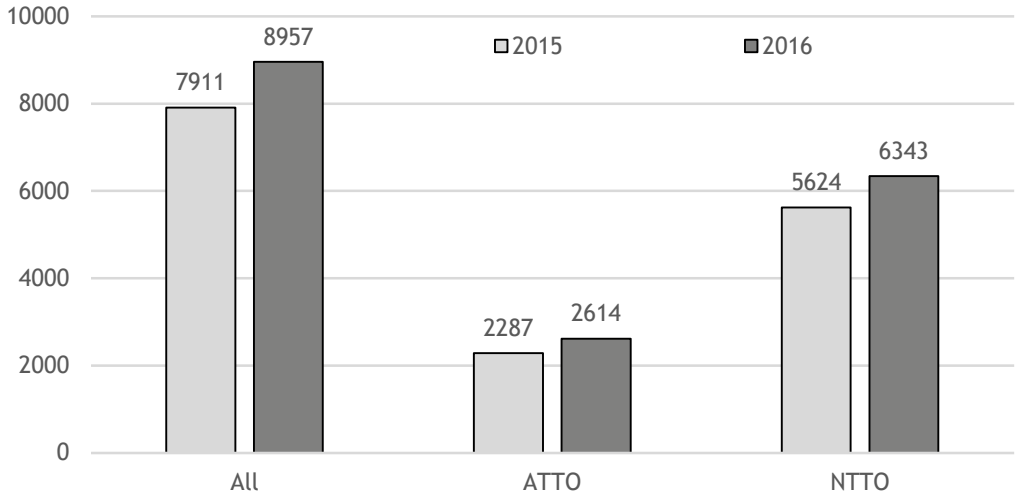
6.2. Employment in Spin-offs and Start-ups [12]

In 2015, the Spin-offs and Start-ups connected to the TTOs employed 7911 people; this number increased to 8957 in 2016 (a 13% increase). The average of the 2 years was 8434. The top 3 TTOs in this category were responsible for 71% of the reported employee numbers, with an average of 2000 employees in each case (based on average numbers for the 2 years).

[11] Note: 2 NTTOs and 2 ATTOs did not provide meaningful data for this question and were excluded from the analysis shown in Table 5.
[12] Note: 2 NTTOs and 1 ATTOs did not provide meaningful data for this question and were excluded from the analysis shown in Figure 25.

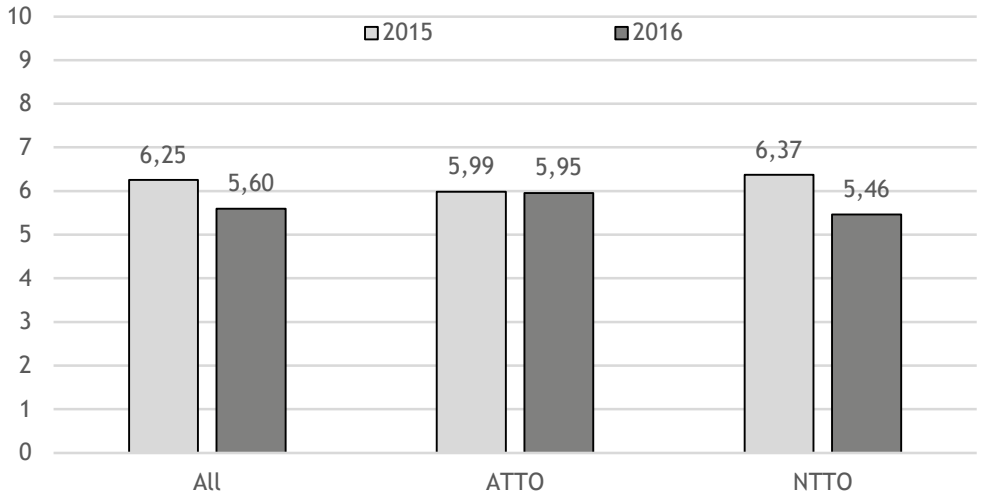
Around 29% of employees were employed by companies connected with ATTO companies and 71% in the NTTO companies – see Figure 24.

Figure 24: Employees (total) in spin-offs/start-ups, 2015 and 2016



The average number of employees in the new companies connected with TTOs was 6.25 in 2015 and 5.6 in 2016. There was virtually no difference in the average number of employees in the ATTO's companies and the NTTO's companies in 2015, and in 2016 the difference was 0.8 employees (see Figure 25).

Figure 25: Average size of spin-offs/start-ups (FTE), 2015 and 2016



6.3. Total turnover and exports of Spin-offs and Start-ups [13]

Seventeen (17) TTOs reported positive data for the turnover of the companies that are connected to them (this is 20% of all TTOs in the survey), which was a total of €214M in 2015 and €281M in 2016, a further 28 TTOs reported 'zero' turnover and a further 40 TTOs did not respond to the question. The companies connected to the NTTOs contributed 96% of this total in both years.

6.4. Business activity of spin-offs/start-ups [14]

The distribution of the companies by business sector is shown in Figure 26. In both years the largest number of new companies were operating in the 'ICT/Software / Digital Media' business sector, and this was true for both ATTO and NTTO companies. The next most popular sector in 2015 was 'Agri-food,' followed by 'Diagnostics and Medical devices', 'Energy/Environment/ Sustainability', 'Pharmaceuticals', 'Microelectronics/Robotics' and 'Nanotechnology and New Materials'. In 2016 the next most popular sector was 'Energy/Environment/ Sustainability', then 'Diagnostics and Medical Devices', 'Agri-Food', 'Microelectronics / Robotics', 'Pharmaceuticals' and 'Nanotechnology and New Materials'. These orders of popularity have ignored the 'other' category.

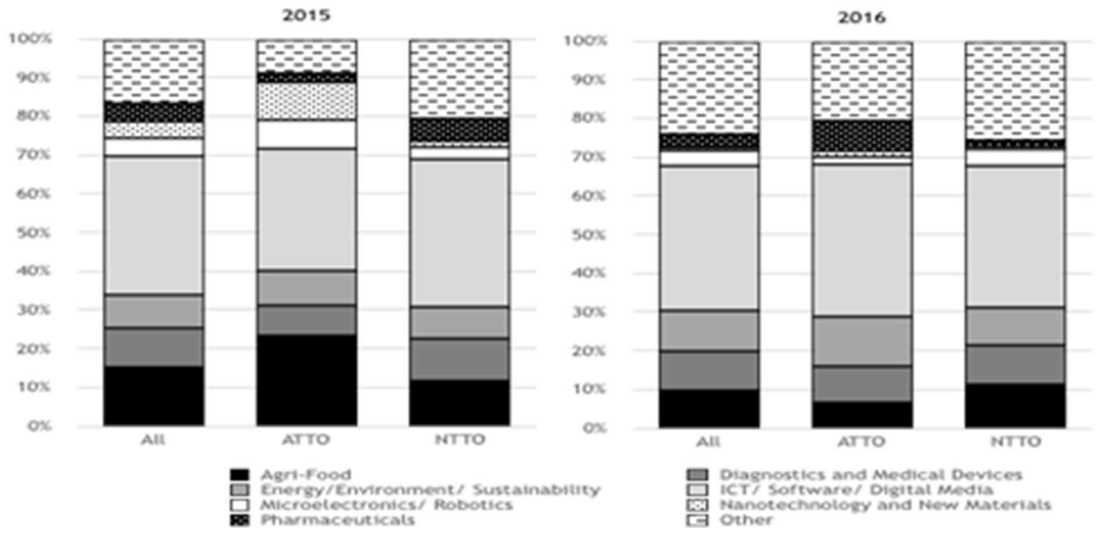


Figure 26: Business activities of new TTO spin-offs/start-ups in 2015 and 2016

[13] Note: Where TTOs provided data for only one year (2015 or 2016), the rate of change of employees between these years was used to calculate an estimate of the turnover in the other (unreported) year.

[14] Note: no meaningful data was provided by 24 NTTOs and 10 ATTOs relating to activity in 2015, and 30 NTTOs and 12 ATTOs for 2016; therefore these TTOs were excluded from the analysis shown in Figure 27. The figures provided in the survey were converted to percentages and where less than a combined total of 100% was indicated by the TTOs in their responses, the shortfall was assumed to occur in the 'other' category.

There were some differences in the business activities of the ATTO companies and NTTO companies in 2015. In 2015 the second most popular category for ATTOs was 'Agri-Food', followed by 'Nanotechnology and New Materials' but for NTTOs this was 'Other', followed by 'Diagnostics and Medical Devices'. The differences between ATTOs and NTTOs were much less noticeable in 2016.

The changes in this data between years indicate that the areas for new TTO companies can change quite rapidly. In addition to the constant factors that influence these events, such as available expertise and facilities, spin-off and start-up companies may also be set up to take advantage of specific technology or funding opportunities, or other transient conditions. The popularity of new companies in the ICT sector may be due to the lower barriers for new business in this sector - it can be much easier to set up new operations, and products can be developed and launched on the market much faster than in sectors such as Pharmaceuticals or Medical Devices. Considering the 'lifetime' value of the companies in each sector may provide further insight.

APPENDIX 1 - List of Organisations Participating in the Survey.

	Group	Type of Entity	Name of Organisation
1	State/Public University	ISCTE-IUL	Audax
2		Universidade da Beira Interior	Gabinete de Inovação e Desenvolvimento
3		Universidade de Aveiro	UATEC – Unidade de Transferência de Tecnologia da Universidade de Aveiro
4		Universidade de Aveiro	IEUA - Incubadora de Empresas da Universidade de Aveiro
5		Universidade de Coimbra	DITS - Divisão de Inovação e Transferências do Saber
6		Universidade de Évora	Gabinete de Apoio ao Empreendedorismo e Transferência de Tecnologia
7		Universidade de Lisboa	TecLabs - Direção de I&D da Faculdade de Ciências da Universidade de Lisboa
8		Universidade de Lisboa	TT@IST – Transferência de Tecnologia do IST Técnico Lisboa
9		Universidade de Trás-os-Montes e Alto Douro	OTIC-UTAD (TTO and GAPI)
10		Universidade do Algarve	CRIA - Algarve TransferTECH - Oficina de Transferência de Tecnologia e Conhecimento da Universidade do Algarve
11		Universidade do Minho	TecMinho
12		Universidade do Porto	U. Porto Inovação
13		Universidade Nova de Lisboa	Research and Innovation Accelerator
14		Universidade Nova de Lisboa	Gabinete de Apoio ao Empreendedorismo
1	Private University	Universidade Católica Portuguesa	Spinlogic
1	Public Polytechnic Institute	Instituto Politécnico da Guarda	Unidade de Investigação para o Desenvolvimento do Interior (UDI/IPG)
2		Instituto Politécnico de Beja	Centro de Transferência de Conhecimento
3		Instituto Politécnico de Bragança	Gabinete de Promoção do Empreendedorismo
4		Instituto Politécnico de Coimbra	
5		Instituto Politécnico de Leiria	CTC/OTIC – Centro de Transferência e Valorização do Conhecimento
6		Instituto Politécnico de Lisboa	Projetos Especiais e Inovação (GPEI)
7		Instituto Politécnico de Portalegre	Coordenação Interdisciplinar para a Investigação e Inovação (C3i) e BioBIP - Bioenergy and Business Incubator of Portalegre

	Group	Type of Entity	Name of Organisation
8		Instituto Politécnico de Setubal	
9		Instituto Politécnico de Tomar	OTIC.IPT Unidade de Transferência e Valorização do Conhecimento
10		Instituto Politécnico do Porto	POLITIC – Politécnica na Transferência de Tecnologia e Conhecimento
1	Technology transfer valorisation centre and/or centre of technological interface and/or centre of technology-based incubation	Centro de Valorização e Transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO	AIBILI - Associação para Investigação Biomédica e Inovação em Luz e Imagem
2		Centro de Valorização e Transferência de Tecnologia	Associação CCG/ZGDV - Centro de Computação Gráfica
3		Centro de Valorização e Transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO	Associação Fraunhofer Portugal Research
4		Centro Tecnológico/CIT - CENTROS DE INTERFACE TECNOLÓGICO	CENTIMFE - Centro Tecnológico da Industria de Moldes, Ferramentas Especiais e Plásticos
5		Centro de Valorização e Transferência de Tecnologia	CeNTItvc - Centro de Nanotecnologia e Materiais Técnicos, funcionais e Inteligentes
6		Centro Tecnológico/CIT - CENTROS DE INTERFACE TECNOLÓGICO	CITEVE - Centro Tecnológico das Indústrias Têxtil e do Vestuário de Portugal
7		Centro de Valorização e Transferência de Tecnologia	COTHN - Centro Operativo e Tecnológico Hortofrutícola Nacional
8		Centro de Valorização e Transferência de Tecnologia	COTR - Centro Operativo e de Tecnologia de Regadio
9		Centro Tecnológico/CIT - CENTROS DE INTERFACE TECNOLÓGICO	CTCOR - Centro Tecnológico da Cortiça
10		Centro Tecnológico/CIT - CENTROS DE INTERFACE TECNOLÓGICO	CTCV - Centro Tecnológico da Cerâmica e do Vidro
11		Centro de Valorização e Transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO	IBET - Instituto de Biologia Experimental e Tecnológica
12		Centro de Valorização e Transferência de Tecnologia	IMM - Instituto de Medicina Molecular
13		Centro de Valorização e Transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO	INEGI - Instituto de Ciência e Inovação em Engenharia Mecânica e Engenharia Industrial
14		Centro Tecnológico/CIT - CENTROS DE INTERFACE TECNOLÓGICO	INESC MN - Microssistemas e Nanotecnologias, www.inesc-mn.pt
15		Centro de Valorização e Transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO	INESC TEC - Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência
16		Centro Tecnológico/CIT - CENTROS DE INTERFACE TECNOLÓGICO	INESC-ID Instituto de Engenharia de Sistemas e Computadores, Investigação e Desenvolvimento

	Group	Type of Entity	Name of Organisation
17		Centro de Valorização e Transferência de Tecnologia	INL - International Iberian Nanotechnology Laboratory
18		Centro de Valorização e Transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO	INOV INESC Inovação - Instituto de Novas Tecnologias
19		Centro de Valorização e Transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO/Centro de Incubação de Base Tecnológica	IPN - Instituto Pedro Nunes e IPN Incubadora
20		Centro de Valorização e Transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO	ISQ - Instituto de Soldadura e Qualidade
21		Centro de Valorização e Transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO	IT - Instituto de Telecomunicações
22		Centro de Valorização e Transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO	ITeCons - Instituto de Investigação e Desenvolvimento Tecnológico para a Construção, Energia, Ambiente e Sustentabilidade
23		Centro de Valorização e Transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO	PIEP - Associação Polo de Inovação em Engenharia de Polímeros
24		Centro de Valorização e transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO	TTU - I3S
25		Centro de Valorização e transferência de Tecnologia	UC BIOTECH
26		Centro de Valorização e transferência de Tecnologia/CIT - CENTROS DE INTERFACE TECNOLÓGICO	UNINOVA - Instituto de Desenvolvimento de Novas Tecnologias
1	Technology based incubation centre	Centro de Incubação de Base Tecnológica	CATAA - Associação Centro de Apoio Tecnológico Agro- Industrial
2		Centro de Incubação de Base Tecnológica	Centro de Incubação e Aceleração de Évora
3		Centro de Incubação de Base Tecnológica	Centro de Incubação e Aceleração Portugal Global
4		Centro de Incubação de Base Tecnológica	CIEBI/BIC - Centro de Inovação Empresarial da Beira Interior
5		Centro de Incubação de Base Tecnológica	Évoratech - Incubadora de Base Tecnológica de Évora
6		Centro de Incubação de Base Tecnológica	FabLab Coimbra
7		Centro de Incubação de Base Tecnológica	GreenValley FoodLab
8		Centro de Incubação de Base Tecnológica	IDDNET - Incubadora D. Dinis

	Group	Type of Entity	Name of Organisation
9		Centro de Incubação de Base Tecnológica	IEMinho - Instituto Empresarial do Minho
10		Centro de Incubação de Base Tecnológica	IET - Instituto Empresarial do Tâmega
11		Centro de Incubação de Base Tecnológica	Incubadora de Moda e Design da Fábrica de Santo Thyrso e Centro de Empresas e Inovação
12		Centro de Incubação de Base Tecnológica	INCubo - Incubadora de Iniciativas Empresariais Inovadoras
13		Centro de Incubação de Base Tecnológica	INOVISA
14		Centro de Incubação de Base Tecnológica	MADAN PARQUE - Associação Parque de Tecnologia Almada -Setúbal
15		Centro de Incubação de Base Tecnológica	NERSANT -Associação Empresarial da Região de Santarém - Start-up Santarém
16		Centro de Incubação de Base Tecnológica	OPEN – Associação para Oportunidades Especificas de Negócios
17		Centro de Incubação de Base Tecnológica	Sines Tecnopolo - Associação Centro de Incubação de Empresas de Base Tecnológica Vasco da Gama
18		Centro de Incubação de Base Tecnológica	Spinpark - Centro de Incubação de Base Tecnológica
19		Centro de Incubação de Base Tecnológica	Start-up Braga
1	Regional/local incubators	Parque de Ciência e Tecnologia	Centro Empresarial - Centro Municipal de Cultura e Desenvolvimento de Idanha-a-Nova
2		Parque de Ciência e Tecnologia	IERA - Incubadora de Empresas do Município de Ílhavo
3		Parque de Ciência e Tecnologia	IERA - Incubadora de Empresas do Município de Ovar
4		Parque de Ciência e Tecnologia	Incubadora de Empresas do Município de Águeda
5		Parque de Ciência e Tecnologia	OPEN- Associação para Oportunidades Específicas de Negócio
1	Science and technology parks	Parque de Ciência e Tecnologia	AVEPARK - Parque de Ciência e Tecnologia, SA EM
2		Parque de Ciência e Tecnologia	Biocant Park
3		Parque de Ciência e Tecnologia	BLC3 - Centro Bio: Bioindústrias, Biorrefinarias e Bioprodutos
4		Parque de Ciência e Tecnologia	Creative Science Park - Aveiro Region
5		Parque de Ciência e Tecnologia	Feira Park- Parque de Ciência e Tecnologia de Santa Maria da Feira

	Group	Type of Entity	Name of Organisation
6		Parque de Ciência e Tecnologia	PCTA - Parque de Ciência e Tecnologia do Alentejo, S.A.
7		Parque de Ciência e Tecnologia	Regia Douro Park, Parque de Ciência e Tecnologia
8		Parque de Ciência e Tecnologia	Sanjotec - Centro Empresarial e Tecnológico
9		Parque de Ciência e Tecnologia	TAGUSVALLEY - Parque Tecnológico do Vale do Tejo
10		Parque de Ciência e Tecnologia	UPTEC - Parque de Ciência e Tecnologia da Universidade do Porto

PART 2 - International Benchmarking of Portuguese TTOs

TABLE OF CONTENTS

TABLES

Chapter 0. Introduction & Summary

The purpose of this Report is understanding the relative performance and the critical features of the technology transfer system in Portugal and other relevant international systems, so that this information can be used to inform a new national strategy to support technology transfer in Portugal.

Countries were chosen to compare their technology transfer systems and activity with that of Portugal. The closest comparator countries were Switzerland, Ireland, Denmark, Czechia and Israel, while research was also conducted on Belgium and Sweden. Data was collated which showed trends in activities and indicated where Portugal was similar and different from the comparator countries, particular differences were noted in the number of TTOs and number of spin-off companies generated, which were higher in Portugal.

Examples of leading TTOs within the comparator countries were selected and studied to reveal their operations and key features. These TTOs were affiliated with the Karolinska Institute in Sweden, The Technical University of Denmark and the Vlaams Instituut voor Biotechnologie in Belgium. These studies revealed key features, including: association with recognized research excellence; attachment to large scale research assets; degree of autonomy; national strategic importance of innovation and technology transfer, adoption of toolkits, specialized technology base, financial independence, entrepreneurship and spin-offs; and Networked Ecosystems.

The technology transfer system in Portugal was studied in further details through analysis of the data gathered and presented in the first 2Bio report for this work ('Analysis of the Activities of Portuguese TTOs 2015-2016', where the major trends were observed and placed in the context of the international benchmarking study. Interviews were conducted with selected Portuguese TTOs and industry representatives in order to how IP-active TTOs operate (including the challenges), and how Portuguese industry perceives the functionality of the national TTO infrastructure. These interviews were summarized, and the key points noted.

The report concludes by presenting the relevant selected features from the analysis and discussions relating to the current state of the Portuguese TTO infrastructure, including relevant challenges that should be considered for strategies intended to strengthen and improve this sector.

Chapter 1. International benchmarking: technology transfer Infrastructures

The initial task for this work was to identify those international systems that are relevant as comparators to Portugal's, considering factors such as population and economy size, state of advancement and existing evaluations of innovation performance. Research was performed to identify objective data that describes the key technology transfer performance features of the most relevant countries. Where useful data was obtained, this was then used to perform an objective comparison of key performance between Portugal and each of the selected comparator countries.

1.1. Selection of Appropriate International Systems for Comparisons

A cohort of countries was identified that were regarded as a reasonable comparator for Portugal in order to 'benchmark' its technology transfer activities. In order to select these countries, multiple factors were considered including: national population size, size of the economy (GDP) advancement of the economy (HDI[15]), intellectual property output, geographical location, availability of data relevant to innovation and technology transfer, and objective published opinions.

Portugal's population has recently been reported as 10.27 Million[16] by the IMF's World Economic Outlook (WEO)[17]. A search was conducted of the WEO database, to find countries with populations within 2 million of Portugal's and that have advanced economies (i.e. an HDI[18] index greater than 0.8). The search returned the following countries: Israel (8.58 Million); Switzerland (8.61 Million); Austria (8.766 Million); Belarus (9.45 Million); Hungary (9.66 Million); United Arab Emirates (9.68 Million); Sweden (10.05 Million); Czechia, the former Czech Republic (10.63 Million); Greece (11.12 Million); and Belgium (11.56 Million).

A further search was conducted of the WEO database to determine the GDP of these counties and compare this with Portugal, which is listed as US$238B in the WEO database. The results were: Israel (US$369B); Switzerland (US$703B); Austria (US$457B); Belarus (US$60B); Hungary (US$155B); United Arab Emirates (US$424B); Sweden (US$551B); Czechia (US$242B); Greece (US$219B); and Belgium (US$533B).

[15] Human Development Index (HDI) combines an economic measure, with other measures, including life expectancy and education. Advanced economies are regarded as having an HDI score above 0.8 [REF]
[16] Data current as of August 2019.
[17] The WEO publication is available in full on the IMF's website, www.imf.org. Accompanying it on the website is a larger compilation of data from the WEO database than is included in the IMF Data Mapper
[18] 2018 Human Development Report by the United Nations Development Programme (released on 14 September 2018) calculates HDI values based on estimates for 2017.

Countries with GDP that was significantly lower than Portugal's were regarded as irrelevant to this work, therefore Belarus, Hungary and Greece were ignored. The IP activity of the remaining countries was investigated using OECD data on patents filed (annually) per million population. The score for Portugal is 77, all countries in the group had a higher score than this except United Arab Emirates (UAE) which was much lower at 9. On this basis the UAE was ignored.

The remaining countries in the cohort were Israel; Switzerland; Austria; Sweden; Czechia (Czech Republic); and Belgium

Other countries were considered for comparison based on their presence in Portugal's geographic region (Europe) where they had a notable performance in Innovation or technology transfer (which had been noted independently). According to the EU's European Innovation Scoreboard website[19], Sweden is the EU's innovation leader in 2019, and Finland, Denmark and Netherlands are also seen as 'Leaders' while Ireland, UK, France, Germany, Belgium, Austria, and Luxembourg are scored as 'Strong Innovators'. According to the Scoreboard Portugal is scored as a 'Moderate Innovator'. The Scoreboard takes into account the infrastructure and activities related to innovation, such as doctoral students, and SME's collaborating with universities; however, it does not reflect data that is specific to technology transfer. A rapid investigation of Luxembourg revealed that it has a single 'research active' university, whose TTO has been responsible for a relatively low level of technology transfer. Following this research, Ireland, Netherlands, and Denmark were added to the cohort which resulted in the following list of potential comparator countries: Israel; Switzerland; Austria; Sweden; Czechia (Czech Republic); Belgium, Ireland, Netherlands and Denmark. (9 countries).

Further research into the technology transfer activities within the cohort of potential comparator countries revealed that strong data sources were available from only some of the group. Switzerland, Ireland, Denmark and Czechia publish the most comprehensive data on technology transfer from their publicly funded research. Annual reports (supported with data tables) are published by government departments or by publicly funded national Technology Transfer associations. These countries have therefore been selected to provide the core of the comparator data for this work. Significant information, albeit less comprehensive, was also available for Israel, Sweden and Belgium.

Summaries of technology transfer practices, and descriptions of relevant key performance data (taken from the reports) is described in the following sections.

[19] see https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en

1.2. Switzerland's Technology Transfer System

Switzerland's current technology transfer system has its roots in the 1990s when its universities and academic research institutes established a professional framework to support both cooperation with the private sector and the commercialization of research results. The average foundation date of the Swiss Technology Transfer Offices (TTOs) is 2000.

Switzerland has 12 Universities, and 8 universities of applied sciences (UAS)[20]. The Swiss Technology Transfer Association (swiTT)[21], produces an annual report of the technology transfer activities of the Swiss public research organizations (which are termed PROs), which includes the Universities, the UAS and 3 public research institutes (RI). The report covers multiple performance indicators, including research contracts, patent applications, IP agreements and IP license income. Relevant data has been extracted from the 2017 swiTT Report and is summarized in Table 1. The 2017 report was chosen because it is based on data from 2016, which is the best comparison for the original ANI survey period.

Name of Institution	Type	Total Research Contracts	Invention Disclosures	Priority Applications	No of LOAs	LOA Revenue	Active LOAs at year end	Spin-offs
ETHZ	Uni	593	215	109	78	€5,883,400	1,487	25
EPFL	Uni	251	149	100	58			20
Uni Geneva	Uni	90	52	10	15			2
Uni Lausanne	Uni	190	28	9	2			0
Empa	RI	177	28	14	13	€3,873,200	110	1
PSI	RI	158	12	6	5			1
Eawag TT	RI	106	2	2	0			3
BFH	UAS	262	5	1	4	€27,600	18	2
HSLU	UAS	N/A	3	N/A	0			0
FH OST-NTB	UAS	75	0	0	0			1
ZHAW	UAS	N/A	N/A	N/A	0			2
Average		211	49	28	16			5
Total		2113	543	279	191	€9,784,200	1,615	62

Table 1. Switzerland: TTO performance 2016

[20] https://en.wikipedia.org/wiki/List_of_universities_in_Switzerland
[21] see: www.swiTT.ch.

The swiTT report is largely representative of the Swiss technology transfer (TT) activity, as it captures data from virtually all of the TTO active organizations in Switzerland, comprising 10 Universities (including the two Federal Institutes of Technology), six universities of applied sciences (UAS), and three research institutions (RI).

The Swiss TTOs have varying roles and responsibilities depending on the type of PRO it is associated with:

- At **universities**, TTOs only handle a part of the collaborative research projects with economic partners. Activities in research and TT at university hospitals are usually closely linked to the respective university, hence the services of these transfer offices are also available to researchers at the hospitals. All of the University TTOs manage intellectual property (IP) and its commercialization, which includes the evaluation of the commercialization potential of products or services based on research results, the protection and management of IP and the licensing or sale of IP to industrial partners. Eight out of nine TTOs at Universities also provide support for the coaching of start-up projects.
- The management of TT activities at the **UAS** varies widely among institutions and individual departments. Some departments or schools have professionals working in a centralized TTO and are able to provide comprehensive data. At other departments or schools, no centralized support functions exist and data are fragmentary or completely lacking. Four out of six UAS TTOs offer support for research collaborations. Five deal with the management of IP. The commercialization of IP and the coaching of start-up projects is supported by two of the UAS TTOs.
- **RI** that participated in the survey have centralized support functions providing TT services for their researchers, the scope of which is variable. All the RI TTOs offer support for research collaborations and all deal with the management and commercialization of IP. Coaching for start-up projects is offered by only one of the RI TTOs.

In common with all the other counties that have been included in this report, Switzerland recognizes the importance of strong R&D for its economy, but also recognizes the attractiveness of a functional technology transfer system to companies that are considering remaining in, or re-locating to, Switzerland; therefore, TTOs also seen as supporting inward investment[22].

The number of IP agreements reported by swiTT for 2016 was 251 deals of which the vast majority (91.2%) were from Universities, 7.2% from RI and 1.6% from UAS. The total number of active licenses under management at the end of 2016 was 1,591, of which 92.9% were handled by the universities, 6.9% by the RI and 0.2% by the UAS. Of these active licenses, 406 (29.1%) cases,

[22] See 'swiTT Report 2017': https://switt.ch/system/files/standard/documents/swittreport2017.pdf

produced license income for the PRO and the researchers involved. In more than half of those cases (266) the license income came from royalties on product sales, indicating mature IP income. The remaining income resulted from other types of license fees, including license issue fees or milestone payments for products still in the development process. These figures reflect the typical situation of licenses granted to industry by PRO. As would be expected for technology transfer by higher education and government research institutes, many of the licensed technologies are at an early stage and require extensive development by the licensees. The data in the swift Report 2017 for license income are incomplete - only half of the participating PROs reported their income, however it is likely that the actual total income of the PROs is not greatly different to this number, as experience suggests that the non-participating institutions are unlikely to have significant licensing incomes.

When licensing to start-up companies, some Swiss PROs may accept equity as a partial compensation for technology licensing, replacing 'up-front' fees or early milestone payments in order to avoid any cash drain from the start-up at the early stage of development. This results in a deferral of license revenues from such licenses until the shares in such start-up companies are sold by the institutions. In 2016, the institutions reported equity transactions for 31 of the 53 new start-up companies created that involved a license or a transfer of technology. In the past years more Swiss PROs have started to accept value for their IP in this way.

The data provided for 2016 shows that the top 5 PROs were responsible for 67% of the IP agreements that were executed in that year. These PROs were ETHZ, EPFL, Uni Geneva, EMPA and PSI. The same group was responsible for 70% of the priority patent applications, 38% of the research contracts, and 49% of the TTO FTE. The top PRO for IP agreements was ETHZ with 78 in 2016 (41% of the total for all PROs in the survey). This indicates that successful technology transfer is unevenly distributed throughout the PROs in Switzerland. The swiTT reports provides anonymous data for license revenues from the participating PROs, this was reported as €9.8 M (CHF 10.6 M) for 216, from a total of 1615 active licence agreements. When the data was broken down by PRO type, the universities were responsible for €5.9 M, or 60% of the total for all PROs included in the report. The Swiss PROs do not publish their research spending or research budgets within their annual reports; therefore, it was not possible to compare the license income versus the research expenditure.

The two highest performing TTOs in Switzerland are EPFL-TTO and ETH-transfer. These TTOs are associated with two universities, Swiss Federal Institute of Technology Lausanne (EPFL) and the Swiss Federal Institute of Technology Zurich (ETHZ), both of which are governed and funded

by the Government of Switzerland, and therefore are most closely aligned with government objectives[23].

1.3. Ireland's Technology Transfer System

Ireland currently has 8 Universities, one of which (Technological University of Dublin) was established very recently in 2019[24] and this was previously an Institute of Technology. There are currently 11 institutes of technology, and 5 specialist and state research organizations. The Irish Government refers to these institutes collectively as Research Performing Organizations (RPOs)

The Irish Government directly supports a network of Technology Transfer Offices (TTOs) which are embedded within most of the RPOs; these TTOs are funded through the government's Technology Transfer Strengthening Initiative which is managed by Knowledge Transfer Ireland (KTI) on behalf of Enterprise Ireland[25]. This directed approach to technology transfer, developed from a drive to improve the economic effectiveness of Ireland's research investment beginning in 2012. This approach replaced the previous system which was relatively 'ad hoc' and fragmented.

Knowledge Transfer Ireland (KTI) is an Irish Government Agency which provides support for technology transfer and commercialization of research throughout Ireland, working through the TTOs within the national Research Performing Organizations (RPOs). KTI has conducted an annual survey of the RPOs since 2012. The survey response is relatively comprehensive, which is consistent with the expectations set out in Irish Government's National IP Protocol[26] that the PROs will be co-operative with the government in recognition of receiving funding and support.

The 2016 KTI Survey has been analyzed for this report[27], this report was chosen as the best comparison with the ANI survey period (2015/2016). In 2016, 24 RPOs provided a return and only 2 RPOs did not respond, therefore the data is highly representative of the technology transfer activity of Irish RPOs in this year.

The report includes multiple performances indicators, including research expenditure, research contracts, Patent applications, IP agreements and IP licensee income. The data from the 2016 KTI Report is shown in Table 2.

Annual research expenditure across Ireland's 24 RPOs in 2016 was reported at €534 million. This represents the total expenditure on all types of basic and applied research in Irish RPOs from all funding sources: government, industry, non-profit foundations, etc.[28].The University sector

[23] https://en.wikipedia.org/wiki/ETH_Board

[24] TUD was established in 2019 and therefore does not feature in the data collected in 2016 that is discussed in this document.

[25] See: 'Ireland's National IP Protocol 2019: a Framework For Successful Research Commercialization' p56. https://www.knowledgetransferireland.com/Reports-Publications/Ireland-s-National-IP-Protocol-2019-.pdf

[26] See: 'Ireland's National IP Protocol 2019: a Framework For Successful Research Commercialization' p47.

[27] Annual Review & Annual Knowledge Transfer Survey 2016 published by KTI Knowledge Transfer Ireland. https://www.knowledgetransferireland.com/About_KTI/Reports-Publications/KTI-Review-and-Annual-Knowledge-Transfer-Survey-AKTS-2016.pdf

[28] the figure excludes any academic costs dedicated to research, costs of administrative support and capital expenditures on new equipment, buildings or land

accounted for most of the research expenditure, at approximately 77% (€411 million). The Institutes of Technology sector accounted for approximately 11% (€60.5 million) of the State's expenditure on research. The Specialist Institute sector (RCSI, NCAD, NCI) and the State Research Bodies (Marine Institute and Teagasc) accounted for the remaining 12%.

Table 2. Ireland TTO Performance 2016

Name of Institution	Research Expenditure	Type	Research Contracts	Income from Research Contracts	Inv. Discl.	Priority Appl.	LOA	Total active LOAs	LOA Revenue	Spin-offs
Dublin City Uni	€35m	Uni	105	€2,356,200	35	14	30	725	€1,620,000	1
Maynooth Uni	€23m	Uni	72	€228,384	12	5	7			2
NUI Galway	€52m	Uni	71	€3,152,038	54	10	11			5
Trinity College Dublin	€91m	Uni	151	€4,548,608	53	13	28			3
Uni College Cork	€96m	Uni	65	€10,598,500	65	12	22			4
Uni College Dublin	€81m	Uni	152	€4,178,958	65	21	22			3
Uni of Limerick	€30m	Uni	83	€3,624,733	43	14	14			2
National College of Art and Design	€0.2m	SSRO	19	€56,852	5	4	0	204	€1,053,000	0
National College of Ireland	€0.1m	SSRO	11	€0	3	0	2			1
Royal College of Surgeons	€18m	SSRO	21	€1,423,573	15	2	8			0
Marine Institute	€4.7m	SSRO	0	€0	0	0	0			0
Teagasc	€41m	SSRO	196	€8,768,775	20	3	6			1
Athlone I o T	€3m	IoT	191	€378,817	5	0	5		€27,000	0
Cork I o T	€13m	IoT	173	€2,588,401	20	3	5			2
Dublin I o T	€15m	IoT	86	€755,000	39	11	11			2
Dundalk I o T	€1.3m	IoT	28	€0	2	0	2			1
Galway-Mayo I o T	€1.7m	IoT	23	€100,558	1	0	0			0
Blanchardstown I o T	€0.5m	IoT	6	€84,602	0	0	2			0
Carlow I o T	€2.1m	IoT	79	€157,444	8	0	0			0
Tralee I o T	€2m	IoT	22	€224,154	3	0	0			0

Tallaght I o T	€1.7m	IoT	40	€235,923	0	0	3			0
Limerick I o T	€1.6m	IoT	35	€84,343	4	0	1			0
Letterkenny I o T	€0.8m	IoT	27	€43,000	0	0	0			0
Waterford I o T	€16m	IoT	328	€1,071,720	9	4	7			1
Average	€22m		83	€1,860,858	19	5	8	465	€900,000	1
Total	€534m		1984	€44,660,583	461	116	186	929	€2,700,000	28

In 2016, the RPOs reported 461 invention disclosures, 116 new priority patent applications, 1984 new commercial research contracts and 186 new IP agreements (Licence, Option or Assignment - LOA). The University sector executed the greatest proportion of LOAs (72%). The total number of LOA agreements active at the end of 2016 was 929, 725 of these (78%) were in the University sector and 204 (22%) from the Institutes of technology and Specialist & State Research Organisation (combined). Software licenses account for 33% of the total, versus 23% for patented IP, therefore there are 1.43 times more software than non-software agreements.

In 2016, the combined IP revenue for all participating RPOs was €2.7 M, which was 0.5% of the RPO's reported research budgets. The Universities reported a combined revenue of €1.62 M (a 60% share) from IP agreements, the SSRO's reported €1.053 M (39%) and the IoT's €0.027 M (1%). Three RPOs realized revenue from the sale of spin-out company equity and one achieved a dividend return, the total revenue from equity sales and dividends was just approximately €3 M. The Income form research contracts was much higher, at a national total of €44.7 M, accounting for around 8.4% of the National research budget.

Comparing the three different types of RPO, the Universities dominate the existing IP portfolios (88%) and new filings (77%), and also the number of existing IP agreements (78%) and new agreements (72%); however, Universities only account for 35% of new research contracts and 64% of the income from research contracts. The specialist and state research organizations account for 11% of the National research budget, and their patenting activity is largely in line with this (6% of existing patents and 8% of new filings) as is the number of research contracts (12%); however, their share of the income from IP agreements (39%) and from Research contracts (23%) is a greater proportion than would be anticipated from the research budgets. This suggests that the Specialist and State Research Organizations work more effectively with industry and make more efficient use of their IP - this may be due to their ability to focus on specific research sectors compared with universities or Institutes of technology, allowing them to specialize. The Institutes of Technology are responsible for to majority of the research contracts (52%), with their contracts

yielding €5.7 M (13% share of all RPOs) suggesting that their priorities are in establishing high numbers of collaborations with industry rather than generating fiscal value.

It is clear that the technology transfer landscape in Ireland is relatively heterogeneous, when examined by RPO type, and when studied at the individual TTO level it is even more so. A good example of this is University College Cork, the leading RPO for research contract income, which generated €10.6 M, or a 24% share of the income from all 24 RPOs that participated in the survey. The top 5 RPOs for this metric were responsible for €31.7 M of income, or 71% of the total income for all 24 RPOs.

KTI has developed innovative infrastructure and tools to support are believed to have supported the improvements in the technology transfer rates seen in the country since 2012. Some good examples of this are the creation of a Hub for the network of TTOs, which is promoting good technology transfer practices and improving connectivity. KTI has also supported the development and access to 'model agreements'. These are template agreements including 'standard' terms and clauses, developed in consultation with TTOs, and companies, they are similar in concept to the 'Lambert Agreements' used in the UK. KTI's model agreements were designed with input from RPOs and industry and are intended to simplify and speed up the process of IP agreements, which in turn would increase the flow of technology transfer. One of the most effective improvements since 2012 is the annual KTI survey, which provides transparency for all the stakeholders involved in technology transfer in Ireland, and which provides perspective on these activities, it also allows RPOs to understand their relative performance.

Alison Campbell, the director of KIT, believes that technology transfer Ireland is performing above reasonable expectations "Research is increasingly industry-focused with a lot of entrepreneurial students in third-level institutions collaborating with commercial partners," she says. Between 20 and 30 spin-out companies a year have been created over the past five years from research in Irish public institutions. These spin-outs have created over 900 jobs.

Alison Campbell highlights two important factors in this success; the well-established network of technology transfer officers working at the interface of institutions and commercial partners; and, the adoption of a national IP protocol in 2012, which has recently been updated. The protocol sets a benchmark for good practice in the commercialization of valuable intellectual property on terms that are fair to both researchers and businesses [29].

1.4. Denmark's Technology Transfer System

Danish public research infrastructure consists of universities, government research institutions and public research hospitals. The transfer of IP between these publicly funded research

[29] From the Irish Times, May 30 2019

organizations and industry is governed by legislation that was adopted in 2000 [30]. One of the effects of the law was to abolish the 'professor privilege' to allow public research organizations (PROs) to assert ownership over the IP generated from their research programmes. Other effects were to protect the inventor's rights to share in revenues, to require institutions to protect IP and establish adequate structures for technology transfer, for which government funding has been made available[31]. It is important to note that this funding did not support the Universities spin-out activities, a legacy of this policy was that Danish universities were more predisposed to technology licensing rather than spin-outs[32].

The average date of foundation of TTOs in Denmark is 2004 [33]. The Government established guidelines for university research collaboration with private enterprise in 2005. In 2011, the Government published further guidance as "Guidelines on Private Funding of Public Research". In 2008, a model IP contract toolkit for universities and industry was published[34]. As with KTI in Ireland, the inspiration for this toolkit came from the UK Lambert Agreements [35], and a selection of model contracts for different types of research collaboration.

Denmark has eight universities. Almost all commercial activity is generated by the four largest universities and the technical university which are: Aalborg University, Aarhus University, Copenhagen University, Danish Technical University, and the University of Southern Denmark (Bengtsson, 2017). Denmark has four regional hospital administrations, which encompass research and university hospitals that are owned by regional authorities.

The output from the Danish TTOs is very visible and public in the sense that each year the output is reported publicly in a report by the Government's Board for Research & Innovation ('Styrelsen for Forskning og Innovation'). The report covers the 8 Universities, two Government research institutes and 5 regional research hospital systems. The data published for 2016 have been reviewed and are summarised in Table 3, below. The original data can be sourced from the Danish

Table 3. Denmark TTO Performance 2016

[30] In Denmark, a new law regarding university commercialization, 'Forskerpatentloven', was issued in 1999 and came into effect in 2000.
[31] See 'Danish Council for Research Policy
International Perspectives on Framework Conditions for Research and Technology Transfer' 2014.
[32] A comparison of university technology transfer offices' commercialization strategies in the Scandinavian countries. Lars Bengtsson. *Science and Public Policy*, Volume 44, Issue 4, August 2017, Pages 565–577
[33] Data was available for U. Copenhagen, U. Southern Denmark, Aarhus U, and Tectra.
[34] 'Johan Schlüter Committee' model contracts.
[35] https://www.gov.uk/guidance/university-and-business-collaboration-agreements-lambert-toolkit

Name of Institution	Type	Research Contracts	Priority Applications	LOAs	Active LOAs at year end	LOA Revenue	Spin-Offs
Copenhagen Business School	Uni	85	0	0	0		0
Technical University of Denmark	Uni	772	77	20	103	€1,412,580	3
IT University	Uni	35	1	0	10	€36,140	1
University of Copenhagen	Uni	418	34	31	184	€851,760	5
Roskilde University	Uni	73	0	1	1	€0	0
University of Southern Denmark	Uni	285	6	4	31	€399,750	3
Aalborg University	Uni	548	14	41	57	€518,830	1
Aarhus University	Uni	610	16	26	76	€587,340	3
The National Geological Survey	GRI	13	0	0	0		0
The Capital Region (Tectra)	Hospital	659	9	13	40	€90,350	5
Central Jutland Region	Hospital	387	4	4	18	€1,690	1
North Jutland Region (Aalborg Hospital)	Hospital	104	2	3	4		0
Region of Southern Denmark (Odense University Hospital)	Hospital	294	1	0	4	€18,460	0
Region Zealand	Hospital	0	1	0	0	€0	0
Average					38		
TOTAL		4283	165	143	528	€3,916,900	22

Government's website[36]. In the 2016 data Copenhagen Business School recorded no IP License/Option/Assignment (LOA) activity, and no data was provided for the State Serum Institute, which is one of the government research institutes, which is therefore not included in the data summary. The reporting is standardized and all Danish TTOs report annual data for invention disclosures, applied patents, approved patents, current patent portfolio, license deals, spin-offs, number of employees, income and costs, and some other data.

The 2016 data from the 14 participating Institutional TTOs showed that these institutions applied for 165 patents, made 4283 research contracts and entered into 143 LOA agreements. The total value of these agreements was DKK30.1M (€3.9M). These institutes were responsible for 22 spinout companies during the year[37]. This dataset also shows that the total number of 'active' LOAs at the end of 2016 was 528 of which 175 (33%) had generated revenues. The data distinguishes between licence and assignment agreements that are made in respect of software IP or other IP (non-software). The numbers of non-software license and assignment agreements (LA) vs software LAs was in the ratio of 55:19 or 74%:26%. And the respective non-software vs software revenues were DKK 9.494M: DKK12.837M or 43%: 57%. This indicates that the agreements for software IP in Denmark are more valuable than other IP, on average.

The data shows that Aalborg University, the University of Copenhagen, Aarhus University, the Technical University of Denmark are in a group of four TTOs (29% of the TTOs in the survey) that have the greatest technology transfer activity, being responsible for 81% of the LOAs in 2016 and 86% of the LOA revenue. The oldest TTOs are The Technical University of Denmark (including the former Risø) and the University of Aarhus (including the former Foulum). Roskilde University and Copenhagen Business School have virtually no technology transfer activity due to the fact that they specialize in the social sciences and the humanities, where it is rarely possible to patent research results. The IT University has a very modest research budget compared with other universities which limits its technology transfer activity[38].

The Technical University of Denmark (DTU) is the country's most prolific institution for patent applications, research contracts and LOAs (which generated €1.4M in 2016). DTU is regarded as one of the leading engineering universities in Europe, and its basic research is focused on the physical sciences and industries such as agriculture, management, transport and construction. 'DTU Tech Transfer' has a strong track record, with the university having established around 2,200 new companies since 1999, which have generated more than DKK 7 billion in turnover and around 2,700 new jobs. The University provides a wide range or programmes and services to support

[36] https://ufm.dk/publikationer/2018/viden-til-vaekst-offentlig-privat-samspil-om-forskning-2018
[37] Spinouts in Denmark: The data on spin-outs is indicative only for the institutions that are part of the survey; however, it is unlikely to be representative of total spin-outs from public research. This is due to Danish government rules that discourage universities from spinning out companies. According to Bengtsson (2017), spin-outs are therefore more likely to occur in science parks, which are not included in the survey.
[38] Vidensamarbejde under lup – Evaluering af universiteternes erhvervssamarbejde og teknologioverførsel. Forskning og Innovation: Analyse og Evaluering 19/2014

collaboration with industry, development of new technology and IP and the creation of new business (such as spin-offs). For further information on DTU see the 'Case Studies' section of this Report.

Aarhus University (AU) is also among the leading universities for technology transfer in Denmark. In 2017 AU announced that it was beginning a collaboration under an 'open innovation' platform. The first phase is a project on smart materials in which university researches and companies will collaborate and share their research without patenting. This radical approach is an attempt to remove any IP-based impediments to the flow of ideas and technology into industry and ultimately benefit the economy and society. The plan is to expand this approach into all other research areas if this first phase is successful. The impact of this initiative is currently unknown; however, the university has acknowledged that it will continue to protect its most valuable IP assets (including smart materials), through 'traditional' technology transfer activities [39].

The Danish technology transfer infrastructure gives full recognition to hospitals, which is unusual for the countries that have been considered in this report. Hospitals make a modest but significant contribution the the overall technology transfer effort in the country. The hospital TTO capability has been built since 2009, for example in the Capital Region where a Centre for Innovation and Research (CIR) was established which had responsibilities for a widely dispersed healthcare network in the entire Copenhagen Region of Denmark. TechID 'satellite' units were established within hospitals in the network, such as one at the Clinical Research Centre of the Hvidovre Hospital (a major hospital in the region). The TechID units in the hospitals are supported by 'technology scouts' from the central CIR on a part-time basis (one or two days per week), the scouts work with innovators, and also keep the hospital managers involved, who must oversee the IP and commercial activities on a day-to-day basis (when the scouts are not there)[40].

The Danish Government made a detailed review of its IP commercialization and technology transfer activities in 2014 [41]. The review drew general conclusions from its own national data, and through comparisons with other countries and regions. The review highlighted a number of critical issues that were seen as inhibitors to national success in this area. The issues were: a lack of consistency in the 'success criteria' between the national Institutions, and a suggestion that the most popular measure - licensing revenues - is imperfect due to lengthy intervals between discoveries and commercial success; a misguided drive for Danish universities to file patents regardless of potential commercial value; commercialization in academia is driven by only a very small cohort of motivated 'serial entrepreneurs' which may result in potential loss in value when this group is not involved.

[39] see: https://techtransfercentral.com/2017/12/05/open-innovation-effort-creates-patent-free-playground-to-spur-research/

[40] See: https://www.astp4kt.eu/techid-units-at-the-hospitals-of-copenhagen-region-of-denmark/

[41] Danish Council for Research Policy: International Perspectives on Framework Conditions for Research and Technology Transfer. Published by the Danish Council for Research Policy, 2014. www.ufm.dk

1.5 Czechia's technology transfer system

Czechia (formerly The Czech Republic) is a former communist country, which was established with its current constitution in 1989, up until that point its economy was not tuned to capitalism or the free market, and it is only since then that the country has developed a 'modern' approach to its industrial sector, and in particular how it interacts with the country's universities and research institutes. Czechia has had to accelerate its development in these areas and can reasonably be expected to be still catching up in comparison with its counterparts in Western Europe.

The Czech government published its innovation strategy document in 2016 [42] in which it recognized some structural weaknesses and set out a strategic objective to strengthen the co-operation and interaction between research organizations and the industry, and increase the commercial use of R&D results and knowledge generated by research organizations. One of the issues it identified was that some research sectors such as pharmacology were not aligned with significant demand from the Czech economy (due to the absence of large companies) and therefore support was needed both to encourage new industry sectors and to establish mechanisms and capacity for technology transfer (licensing, contract research) from research

organizations to companies. Nationally-supported technology transfer strategies are strong, but a relatively recent phenomenon in Czechia.

Table 4. Czechia TTO Performance 2016

[42] National Research and Innovation Strategy for Smart Specialisation of the Czech Republic (National RIS3 Strategy)

Name of Institution	Type	Income from Research Contracts	Priority Applications	LOAs	LOA Revenue
Czech Technical University in Prague	Uni	**N/A**	82	55	**N/A**
Technical University of Liberec	Uni	**N/A**	**N/A**	**N/A**	**N/A**
University of West Bohemia,	Uni	€2,301,074	29	2	€238,556
Mendel University in Brno,	Uni	€819,556	5	5	€78,000
Charles University	Uni	€1,114,407	15	4	€43,889
Palacký University	Uni	€953,444	22	1	€27,333
Masaryk University	Uni	€1,390,963	5	5	€19,185
Brno University of Technology	Uni	€6,005,185	26	16	€13,259
University of South Bohemia	Uni	€14,185	3	15	€10,444
VŠB – Technical University of Ostrava	Uni	€4,333,333	24	11	€7,407
Tomas Bata University	Uni	€534,259	13	5	€2,815
University of Pardubice	Uni	€530,630	7	3	€2,000
Czech University of Life Sciences	Uni	€338,370	10	3	€0
The Institute of Organic Chemistry and Biochemistry	RI	**N/A**	**N/A**	**N/A**	**N/A**
Transport Research Centre	RI	€1,150,481	2	1	€3,704
Biology Centre of the Czech Academy of Sciences	RI	€167,519	1	1	€2,222

Institute of Physics	RI	€299,741	9	1	€1,481
National Institute of Mental Health	RI	€823,444	**N/A**	**N/A**	**N/A**
Average		€1,123,376.07	18.42	8.83	€32,164.02
Total		€13,212,926	221	106	€450,296

Czechia has 43 Universities, 26 'Public' 2 'State', 9 'Private' and 6 'For-Profit Private'.The Czech national association for technology transfer (transfera.cz) was established in 2014.[43] Transfera.cz represents Czech research organizations, but also includes industry in its membership, and it publishes a handbook describing its members and their activities. The association lists 18 Technology Transfer Offices, most of which (13) are offices within a university, and in addition 8 associated organizations which perform technology transfer activities. The most recent handbook describes five main performance indicators of its members, namely no. of patent applications filed in the survey year, number of patents granted, number of patents licences 'sold', value of research contracts and income from patent licences[44]. The data from the handbook has been collated and a summary is shown in Table 4. The larger data set is shown in Appendix X.

The data gathered by Transfera.cz for 2016 (reported in the 2017 handbook) shows that 18 Czech universities and institutes were active in technology transfer, the average foundation date for these offices is 2010 (which is the most recent of the comparator countries included in this study). These organizations filed a total of 221 priority patent applications and executed a total of 106 Licence/Option/Assignment agreements (LOAs). The group generated CZK 11.2 Million (€0.45 Million) of income from LOAs and CZK 394 Million (€13.2 Million) from contract research. The top 5 reporting organizations for LOAs generated €0.4 Million income from this activity, or 90% of the total LOA income reported in the survey; however, the Czech Technical University was the most active University according to the number of patent applications (82) and number of LOAs (55) but this university did not provide data on income from LOAs or contract research. Brno University of Technology generated the most contract research income, €6 million, which was 45% of the total reported for all the organizations in the survey; however, Brno was not in the top 5 for LOA income.

The Czech data indicates that research organizations in the Czech Republic are actively engaging in technology transfer; however, the relatively low total fiscal value indicates a low level of maturity in these activities. Interestingly, the high degree of heterogeneity in the data, may indicate that competence in technology transfer has been mastered by only a small minority of

[43] see: http://www.transfera.cz/en/about-us/history/
[44] Overview of Technology Transfer Offices and Other Members of Transfera.cz Published by Transfera.cz, July 2017.

organizations, and that this knowledge and expertise has not yet fully diffused through the national technology transfer networks.

1.6 Israel's Technology Transfer System

Israel's technology transfer activities are based on its universities, hospitals and research institutes. There are 9 universities (UNI) [45], 8 of which have active TTOs, in addition there are 5 active hospitals (H) and three active research institutes (RI). Some of the technology transfer offices that are responsible for managing this activity are amongst the oldest in the world (for example, Yeda, the TTO for the Weizmann Institute was established in 1959); Israel has the oldest established technology transfer infrastructure of all the countries that have been included in this evaluation. A list of Israel's most active TTOs is shown in Table 5.

The Israeli TTO performance in 2016 was reported in the 'Survey of Knowledge Commercialization Companies in Israel 2017 Reports on Inventions, Patents, License Agreements, Income and Startup Companies' [46]. The data does not provide detail at the individual TTO level but does provide information that enables some comparison with the other countries that are included in this report. The average foundation year for the TTOs considered in the report was 1988, which is reflective of the maturity of the TTO infrastructure [47]. The combined income from research contracts (for 19 institutes was €104 Million and the combined income from LOAs was €341 Million, which places it at the top of the list of comparator countries, and is 2.4 times greater (in absolute terms) than the UK, the next highest. The number of Israeli spin-out reported for 2016 is 34, which is not vastly different from the majority of the other comparator countries.

Table 5. Israel's TTOs

TTO Name	Institution	Type	Year Established
Yeda	Weizmann Institute	UNI	1959
Yissum	Hebrew University of Jerusalem	UNI	1964
T3	Technion - Israel Int. of Technology	UNI	2007
Ramot	Tel Aviv University	UNI	1973
Hadasit	Hadassah Medical Organization	H	1986
Ariel Scientific Innovations	Ariel University	UNI	1999

[45] see: https://en.wikipedia.org/wiki/List_of_Israeli_universities_and_colleges

[46] see https://www.cbs.gov.il/en/mediarelease/pages/2018/survey-of-knowledge-commercialization-companies-in-israel-2017.aspx

[47] Foundation dates were obtained from the Startup Nation website (https://finder.startupnationcentral.org/tto_page/ramot)or from individual TTO websites.

TTO Name	Institution	Type	Year Established
NIBN	National Institute for Biotechnology in the Negev	RI	2009
Rambam MedTech	Rambam Health Care Campus	H	2014
Kidum	Volcani Agricultural Institute	RI	1951
Carmel	University of Haifa	UNI	2002
BGN Technologies	Ben Gurion University	UNI	1978
BioRap Technologies	Rappaport Faculty of Medicine (within Technion)	UNI	2001
Tel Hashomer	Sheba Medical Centre	H	1993
Tel Aviv Sourasky Medical Centre	Tel Aviv Sourasky Medical Centre	H	2000
Gavish	MIGAL - Galilee Research Institute	RI	1999
BIRAD	Bar-Ilan University	UNI	1974
Mor Research Applications	Clalit Health Services	H	1994
Average year established			1988

Israel's model for technology transfer is often regarded as one of most successful, due to the value of its startup companies and the high level of licence income generated by TTOs. In this respect the technology transfer landscape is similar in nature to that of the U.S.A., with which it shares many connections, networks and from where the majority of Israeli startup investment and Israeli IP licence income comes.

Each technology transfer company is owned or controlled by its parent university (or other institution). They are private companies that are able to access public sector finance and subsidies, reflecting the strong national innovation policy in the country [48]. The TTOs have also been very successful in interfacing directly with business development vehicles that assist in marketing their IP and many of which have raised investment to finance spinout companies. In this way Israeli TTOs are able to offer early-stage projects a secure runway for commercialization by facilitating access to large-scale funding, commercialization know-how and industry know-how [49].

[48] Private Sector Interaction in the Decision Making Processes of Public Research Policies Country Profile: Israel. see https://ec.europa.eu/invest-in-research/pdf/download_en/psi_countryprofile_israel.pdf

[49] See: Israel's Life Sciences Industry IATI Report 2018

Examples of these organizations (and their affiliations) are:

- Alfred Mann Institute (Technion)
- Hadasit Bio-Hoildings Ltd.
- Integra Holdings (Hebrew University of Jerusalem)
- LinkEdge (multiple institutions, initial partnership with Shaare Zedek Medical Center)
- Momentum, including funds from TATA group and Temaske (Tel Aviv University)
- Startup Nation 2 Enterprise (multiple institutions)

Israel's lack of natural resources has historically driven national research policies towards alternatives for raw materials and towards exporting scientific knowledge, which are major driving forces behind the success of its TTO activities [50]. In Israel the research landscape also includes the military, which concentrates its research efforts on specific areas, which currently includes big data and encryption, ensuring a strong pipeline of innovations in these areas. It is also worth noting that biopharma is a key research area for the universities which underpins Israel's very strong life science industry. Benjamin Soffer, the former chief of T3, Technion's TTO, claims that the Israeli TTO infrastructure is fast and agile and benefits from a strong national framework which prioritizes the removal of bureaucratic roadblocks, he also believes that limited budgets and small tightly-focused teams can often generate innovative, winning approaches in research and small spin-out companies [51]. However Israeli TTOs look compare themselves primarily with their counterparts in the USA and their 'limited budgets' appear to be quite healthy in comparison with those in the comparator counties of this study.

1.7 Sweden's Technology Transfer System

Sweden has 15 Universities [52], for which there are 12 innovation offices which deal with technology transfer and commercialization of research. The universities are: Chalmers Technical University, Gothenburg University, Karolinska Institute (KI), Royal Institute of Technology (KTH), Linköping University, Lund University, Umeå University, Uppsala University, Luleå University, Swedish University of Agricultural Sciences (SLU), Stockholms University and Fyrklövern (a TTO serving Mid Sweden University, Karlstad University, Linnaeus University and Örebro University).

Academic researchers In Sweden own the IP rights from their inventions, rather than their employers (universities)[53]. The persistence of these rights is in contrast with the other countries included in this evaluation, and has some significance to the technology transfer culture in Sweden. One of the effects is that the collection of patenting and licencing data is not routine in

[50] Private Sector Interaction in the Decision-Making Processes of Public Research Policies Country Profile: Israel. see https://ec.europa.eu/invest-in-research/pdf/download_en/psi_countryprofile_israel.pdf

[51] 'Ireland can learn from Israel's technology transfer model'. The Irish Times, Thu, May 30, 2019

[52] See: https://en.wikipedia.org/wiki/List_of_universities_and_colleges_in_Sweden

[53] According to a law passed in 1949 in Sweden, creating the so-called Teacher's Exemption (or 'professor's privilege')

Sweden, as the Universities and institutes have no automatic right to the IP and no requirement to exploit it. This seems is borne out by a relative absence of published information on technology transfer and IP commercialization in Sweden.

The first phase in developing Sweden's TTO infrastructure began in the mid-1990s [54]. Five university holding companies were founded in 1995 from which the activity has grown . The strategy of using holding companies was chosen because the universities were prohibited from investing in companies, and these structures naturally led to the predominant activity being spin-off company formation and growth [55].

Sweden has established an innovation strategy which supports technology transfer and commercialization [56], and the TTO system, which is now included in the strategy, has received government support to expand and add incubation capacity. The Government establishment VINNOVA, its innovation agency, in 2009 [57]. Government funding also supports the infrastructure and activities within the Universities (units), including IP and market validation work, and training for university staff. Government strategy has also encouraged a regional approach to innovation support and TTOs are increasingly working with research outputs and innovators from multiple institutions, a networked approach that improves efficiency, but can risk disenfranchisement.

Table 6. Number of License Deals Reported by Swedish Universities 2004-2013

Institution	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Gothenburg Uni.	0	0	0	0	0	0	0	0	0	0
Karolinska Inst.	3	3	3	0	0	0	0	2	0	0
KTH	0	0	0	0	0	0	1	2	1	3
Linkoping Uni.	0	0	0	0	0	0	0	0	0	0
Lund Uni.	0	0	0	0	0	0	0	0	0	0
Uppsala Uni	0	0	0	5	0	1	1	0	0	0
Total	3	3	3	5	0	1	2	4	1	3

The TTOs offer advice on IP, and commercialization to researchers. If the services provided have significant costs attached, (e.g. patent applications), the TTOs seek remuneration, which can be in the form of equity in a new venture. The researcher, however, is free to choose any partner for commercialization services. The university holding companies work closely with

[54] Jacob, M., *et al.*, (2003) 'Entrepreneurial transformations in the Swedish University system: the case of Chalmers University of Technology', Research Policy, 32: 1555–1568
[55] Deiaco E., *et al.*, (2006) Kartläggning av holdingbolag kring universitet och högskolor. Stockholm: SISTER.
[56] See: https://www.government.se/contentassets/cbc9485d5a3446729632258581182 73b/the-swedish-innovation-strategy
[57] See: https://www.vinnova.se/en/

investment funds to support their downstream operations and spin out activities, these funds are a mixture of public and private money.

Table 7. Number of Spin-offs Reported by Swedish Universities 2004-2013

Institution	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Gothenburg Uni.	3	2	1	1	5	8	7	4	12	8
Karolinska Inst.	7	8	5	1	1	6	4	1	11	5
KTH	0	1	1	0	1	2	5	17	11	23
Linkoping Uni.	9	4	6	9	5	7	9	9	5	10
Lund Uni.	7	6	3	1	4	10	16	16	16	14
Uppsala Uni	3	6	5	2	8	3	2	5	7	2
Total	29	27	21	14	24	36	43	52	62	62

A study of University commercialization activity from 2004-2013, which obtained data from 6 TTOs, has indicated that licencing occurs at a very low frequency and is much less that spin-off company formation [58] (see Tables 6 and 7)

The Karolinska Institute (KI) is one of the leading universities in Sweden and is ranked 41st in the World University Rankings (Times Higher Education supplement), its research activities are focused on the field of human medicine.

KI has secured very high value partnerships with industry; for example, with AstraZeneca it recently established the KI-AZ Integrated Cardiovascular Metabolic Centre (ICMC) with over 70 researchers, the relationship with AstraZeneca provided €16 Million (SEK 172.4 million) in 2017 [59]. In 2014 KI established a 14-year innovation partnership with Philips for hospital technologies which in 2017 was awarded two Horizon 2020 grants from the EU, valued at over €22 million [60].

KI is regarded as having one of the best developed systems for commercializing research knowledge in Sweden [44]; it service researchers in life science, both from KI and other Nordic universities and research centers [61]. Technology transfer activities at KI are managed through a sophisticated system of both 'in-house' and external agency support and has produced highly successful spin-off companies over the years (see the 'Case Studies' section in this report).

[58] A comparison of university technology transfer offices' commercialization strategies in the Scandinavian countries. Lars Bengtsson. *Science and Public Policy*, Volume 44, Issue 4, August 2017, Pages 565–577
[59] See: Karolinska Institutet Annual Report, 2017
[60] See https://www.philips.com/a-w/about/news/archive/case-studies/20190128-patient-first-how-karolinska-university-hospital-is-transforming-to-meet-future-demands-of-healthcare.html
[61] https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/support-measure/karolinska-institutet-innovation

1.8. Belgium's Technology Transfer System

Belgium has 11 Universities which generate the overwhelming majority of the scientific output in the R&D ecosystem [62]. The universities are: Katholieke Universiteit Leuven (KU Leuven), Universiteit Gent (UGent), Universiteit Antwerpen (UA), Vrije Universiteit Brussel (VUB), Universiteit Hasselt (UHasselt), Catholic University of Louvain (UCL), Saint-Louis University, Brussels (USL-B), the University of Namur (UNamur), the Free University of Brussels (ULB), the University of Mons (UMons) and the University of Liège (ULiège). In addition to the universities there is the The Royal Military Academy (KMS- ERM) and a range of scientific institutes, including VIB, imec, iMinds, VITO and Flanders Make.

The six universities of Wallonia and Brussels Regions (ULiege, UCL, ULB, UMons, UNamur and USL-B), are part of the LIEU Network, which publishes an annual summary of its members' technology transfer performance data. This does not provide granular detail of the technology transfer activities of Belgian research organizations, nor does not cover the entire country; however, in the absence of a more comprehensive data set it provides indicative performance data based on more than half of the country's universities.

The LIEU summary for 2016 reports 191 Invention disclosures, 181 Patent filings, 193 research contracts (with companies), 118 LOAs and 15 spin-off companies [63]. No data is provided for income associated with research contracts or LOAs.

The Belgian research system is highly "devolved" due to the country's well-developed federalization. The Belgian regions have authority on research policy for economic development purposes, thus encompassing technological development and applied research as well as all valorization tasks, including strategic research centers and other knowledge centers. The Federal Government is in charge of the federal scientific institutes. Intellectual property (IP) law, and core research programmes such as defense, public health and nuclear energy research are also under federal control.

Innovation policy is developed within the regional governments with each government having an advisory council for science and innovation policy. Implementation of the policies in the Flanders Region is the responsibility of Flanders Innovation and Entrepreneurship (AIO) which provides guidance and support for businesses, including innovation support, while Innoviris and the Agency for Enterprise and Innovation (AIE) take up this role in the Brussels Capital Region and the Walloon Region, respectively [64].

KU Leuven is Belgium's largest university; It is a diversified university and it regularly achieves high rankings in global university surveys. In 2018 KU Leuven reported a total research budget of

[62] Geerts N., Van Langenhoeve, M., Viane, P., Dengis, P. (2014). STI in Flanders. Science, Technology and Innovation Policy and Key figures 2013. Flemish Government, Department Economy, Science and innovation.
[63] See: https://www.reseaulieu.be/en_US/
[64] JRC Science For Policy Report, RIO Country Report 2017: Belgium. European Commission, 2018.

€476 million, 24% of which comes from industrial research contracts (€114 million). In 2018, 117 patents were granted to the University and it generated a license income of €57 million.

The University's technology transfer and commercialization activities are managed by KU Leuven Research & Development (LRD), which was established in 1972. The TTO has launched a myriad of innovative technologies into the market since then. LRD provides a range of services to assist with the dissemination of their research including securing and licensing intellectual property and collaborating with industry. LRD has been instrumental in creating spin-off companies. LRD and Lcie, KU Leuven's entrepreneurial student community, support researchers and students in transforming their innovative ideas and technologies into commercial products and services.

Since 1972, LRD has supported the creation of 128 spin-off companies, directly employing more than 6,700 people [65].

VIB (Vlaams Instituut voor Biotechnologie) is a decentralized research institute that specializes in biotechnology research. This institute, which was established in 1996 by the Flemish Government, is a leader in translational research and technology transfer. VIB is funded by a significant investment from the Flemish Government, for which VIB is expected to generate high quality research (publications), and technology transfers (patents, licensing agreements, startup companies, etc.) [66].

VIB commercializes its technologies through both licencing and spin out strategies, and has created an extensive innovation ecosystem that provides early stage IP support, business planning, proof-of concept, incubation and spin-out funding (for more details of this see the 'Case Studies' section of this Report). In 2011, VIB made 73 invention disclosures and filed 34 new patents. The institute made 83 new LOAs and it generated €15 Million in LOA income. Licensees include (bio)pharma, agrobiotech and food-processing companies and range from SMEs to multinationals. VIB has co-founded a large portfolio of spin-off companies, which in 2018 were responsible for 11 clinical drug programmes. Successful spin-outs include Ablynx. In 2017 the Innovation and Business Unit generated €28.7 million income from industry and spun out Aelin Therapeutics, which raised €27 million.

1.9. Additional TTO Data from UK and Australia

In the UK, all Universities provide annual returns to the Higher Education Statistics Agency (HESA), which is an expert body for UK higher education data, and the designated data body for England. HESA collects data though the Higher Education - Business Community Interaction (HE-

[65] See: 'KU Leuven Facts and Figures'. https://www.kuleuven.be/english/research/about_research/facts-and-figures
[66] See: http://www.vib.be/en/about-vib/organization/Pages/default.aspx

BCI) survey. The HE-BCI returns are a very useful source of technology transfer data for all the UK's universities, including information on patenting, research contracts and licences, options and assignments (LOAs).

Similarly, in Australia the Federal Government's Department of Industry, Innovation and Science conducts its annual National Survey of Research Commercialization (NSRC), which is less comprehensive than the HE-BCI, but covers most of its data categories for technology transfer.

These HE-BCI and the NSRC surveys results relating to 2016 were obtained and the data was analyzed and summarized so that is could be compared with the similar data obtained for other comparator countries. The intention of comparing the TTO data from these two additional countries was to provide additional depth to the evaluation of national trends, and to understand, for instance, if TTO performance could be subject to any discernible limits or standards.

The summary data tables generated for UK and Australia are shown below as Table 8 and Table 9, respectively.

Table 8. UK: HE-BCI Data (selected) 2015/16

Rank Order	UK HE Institution	Invention Disclosures	Priority Applications	Patents Granted	Research Contracts	Contract Income (£m)	LOAs	LOA Income (£m)
1	The Institute of Cancer Research	6	6	5	75	8	52	64
2	The University of Cambridge	266	361	81	714	33	106	12
3	The University of Oxford	361	200	244	2,601	169	1,347	8
4	The Queen's University of Belfast	81	35	18	627	18	55	7
5	University College London	106	100	98	2,242	89	345	6
TOTAL (1-5)		820	702	446	6,259	317	1,905	97
TOTAL (162)		**4,358**	**2,066**	**1,219**	**34,336**	**1,274**	**43,631**	**139**
ranked as % of total		19	34	37	18	25	4	70

Table 9. Australia: NSRC Data (selected) 2016

Rank Order	AUS HE Institution	Invention Disclosures	Research Contracts	Contract Income 2016 AUS$m	LOAs	LOA Income 2016 AUS$m
1	University of Queensland	126	1227	185	44	45
2	CSIRO	88	933	426	74	38
3	Uni of Western Australia	31	88	15	4	12
4	Walter and Eliza Hall I of M R	21	12	6	8	9
5	University of New England	1	48	1	23	8
TOTAL (1-5)		267	2308	633	153	111
TOTAL (111)		1503	16139	1848	533	132
ranked as % of total		18	14	34	28.71	84

1.10. Comparison of Technology Transfer in Comparator Countries.

The comparative data for 2016 from the group of 6 close comparator countries [67] plus UK and Australia was summarized and is shown in Appendix A: Table 10 - 'International TTO Performance'. This relevant element of this data was also 'normalized' with respect to the relative GDP value (relative to Portuguese GDP) in Appendix A Table 11, and also with respect to the relative population size (relative to Portuguese population) in Appendix A Table 12. The main features of the data are described below. The data for 'Institutional Research Funding' (i.e. the total funding that the Institutions receive annually for all activities) was incomplete and therefore unsuitable to make any meaningful comparisons. Comparisons of the other data categories were made and are summarized below.

N.B. The features of the technology transfer systems in the group of 6 countries and of the Case Studies are discussed in Chapter 2, below.

- **Number of Technology Transfer Offices** [68]

The greatest number of technology transfer offices in the countries that were the closest comparators (Portugal, Switzerland, Ireland, Denmark, Czechia and Israel) are to be found in Portugal (85) which was more than three times greater than the next biggest number in Ireland (24) the remaining countries in the group had a very similar number of offices (average 15.5 offices). The larger countries in the comparison had a greater number of offices (UK-162;

[67] Portugal, Switzerland, Ireland, Denmark, Czechia, Israel

[68] The number of technology transfer offices surveyed for the data sets used is not directly comparable to the number offices that claim to perform technology transfer activities in each country; however, the number recorded corresponds to the number of active offices that participated in surveys.

Australia- 111). When GDP was taken into account to pro-rate UK and Australia, their office numbers become closer to those of the other countries (excluding Portugal) with UK at 13.6 and Australia at 18.6. The data indicates that Portugal has a much higher number of active technology transfer offices by GDP then any of the other countries in the comparison.

- **TTO Foundation Date**

The average date of foundation of the responding offices was earliest in Israel (1988) followed by Switzerland (2000). The dates for Denmark (2004), Ireland (2005) and Portugal (2006) were very close, and Czechia's offices were the most recent (2010).

- **Research Contracts**

The number of contracts in the closest comparator countries was varied with Portugal having fewest (913) and Switzerland the greatest (2,113). When GDP was taken into account Denmark and Ireland performed better than Portugal or Switzerland, and Denmark was close to both UK and Australia. Data for income from research contracts was not available for most of the close comparator countries, only Ireland (€44m) and Czechia (€13m). The income reported for Israel was €180m. Research contract income for the larger countries was much greater with UK earning €1.2b and Australia €1.1b.

- **IP and Patents**

Switzerland (543) and Ireland (461) made a similar number of invention disclosures while Israel's was much greater (1,328). The number of priority patent applications was lowest in Ireland (116) and Denmark (165) but similar in Portugal (266), Switzerland (279), and Czechia (221). Israel made a much greater number of applications (635). As expected, the number of invention disclosures and patent applications in UK and Australia was greater. When GDP was taken into account Israel had the highest numbers of invention disclosures and patent applications for the group (including UK and Australia).

- **IP Licence, Option and Assignment Agreements (LOAs)**

The number of LOAs executed during the year (2016) was relatively similar in the closest comparator countries with Portugal having the highest number (266) and Czechia the lowest (106). The LOA income generated in each country did not bear any relationship to the number of LOAs executed annually or the total number of active LOAs (data only available for Switzerland, Ireland, Denmark and Australia). Israel was, by far, the highest earning country from LOAs at €341m, the next highest in the close comparator countries was Switzerland (€10m) and Czechia was the lowest (€0.5m). The UK had the highest number of 43,631 LOAs in the larger group of countries, which

when GDP was taken into account remained much higher than any other country (6,611); and 86% of these are software licences. Income from UK LOAs was €140m.

- **Spin-offs**

Portugal generated the highest number of spin-off companies compared with all the other countries (389) the next highest was Switzerland (62) and the lowest was Denmark (22) - there was no data for Czechia.

Chapter 2. International Technology Transfer Practices

The review of technology transfer infrastructure and performance in the cohort of comparator countries identified in section 1, above, identifies interesting features in the systems studied, and highlighted a number of exceptional TTOs, whose features and performance justify further investigation, and three of these are described below. The goal of this evaluation was to identify key features within the comparator countries and from the Case Studies of the high-performing TTOs that could be considered for relevance to the current technology the transfer ecosystem in Portugal.

2.1. International Case Studies

The TTO activities of Danmarks Tekniske Universitet (DTU), Karolinska Institutet (KI) and Vlaams Instituut voor Biotechnologie (VIB) were selected, based on their national leadership status, with respect to technology transfer.

2.1.1 Case Study - Danmarks Tekniske Universitet

Danmarks Tekniske Universitet (DTU), or in English the Technical University of Denmark, is a leader in the country for new technology development, technology transfer and entrepreneurship. DTU's main focus is on engineering and the physical sciences and its research is primarily connected with industries such as agriculture, management, transport and construction.

Innovation Ecosystem: DTU has launched several initiatives that are intended to support entrepreneurship, many of which are co-financed with private funds or companies. In addition to the more traditional technology transfer services, DTU offers advisory and mentoring services, courses in entrepreneurship, events and other support for culture, incubation, access to facilities and access to capital. The primary goal of technology transfer activities are to nurture new technology and IP and encourage its uptake by industry (through licensing), while the other elements of the ecosystem are aimed at stimulating the establishment of spin-off companies that can take responsibility for commercializing DTU's IP and technology. Further detail of the elements in the ecosystem, including the component programmes can be found in a report produced by DTU in 2018[69].

Industry: DTU provides multiple pathways for companies to collaborate with the university, including sponsoring research programmes, licensing existing IP, participating in a DTU start-up or co-operating with innovative students through the Skylab programme (see below). If companies commission and pay DTU to perform research, the companies own the IP rights as part of the

[69] See: Entrepreneurship at DTU through two decades – initiatives, results and socio- economic impact Analysis prepared for DTU, August 2018. http://www.tt.dtu.dk/about-us/facts-og-figures1#iris-report

contract, whereas companies that part-finance the research must negotiate for the IP rights. DTU has established collaborations with companies such as Novo Nordisk and BASF, although evidence of major industrially sponsored programmes is not made clear by the University.

TTO: The DTU Tech Transfer website currently lists a relatively large complement of 21 staff, who deal with a comprehensive range of TT activities including idea development, project scoping, project development and deal making. The TTO has significant in-house capacity to handle its own patent portfolio with a patent attorney leading a team of 5 patent specialists. The direction of the technology transfer effort is apparently towards licensing to spin-out companies, although licences are also enacted with other (non-university) companies.

Enterprise support: Several organizations offer entrepreneurs from DTU financing and venture capital at different stages of their development. The early stage support provided by the DTU ecosystem includes the DTU Enable Programme, which provides technology development grants; DTU Discovery grants, up to DKK 150,000 to support DTU investigator/ entrepreneurs (Total fund size DKK 5 million per year); DTU Proof-of-concept grant up to DKK 500,000 (Total fund size DKK 6.8 million). In addition to this the DTU Skylab also offers 'Skylab Funding', which is a proof of concept grant of up to DKK 250,000 for student start-ups with high potential 70.

DTU Skylab is DTU's innovation hub which focuses on enabling student innovation and entrepreneurship through the three focus areas: student innovation, company collaboration and academia. This can include smaller student projects, case solving on courses and student start-ups.

DTU Entrepreneurship is a center that focuses on the processes of entrepreneurship, it aims to educate DTU staff in business practices, and how business interacts with technology.

DTU Science Park is a community of start-up companies, growing companies and established companies. The companies are predominantly from 'deep tech' sector. The environment is intended to encourage the exchange knowledge and experience. The Science park is enhanced by Futurebox, a deep tech incubator and accelerator, proving workspace for hardware start-ups and space for industry partners.

Spin-Off Companies

DTU accounts for approximately one third of the spin-offs emerging from Danish research institutions. The university has established around 2,200 new companies since 1999, which have generated more than DKK 7 billion in turnover and around 2,700 new jobs.

[70] 1 DKK = € 0.13, approximately (October 2019)

Examples of DTU spin-off success includes BioGasol, Glycom and Copenhagen Nanosystems.

- **BioGasol:** This company was established in 2006, a DTU spin-off based on technology for converting plant material into ethanol. The company's products including 'Carbofrac' are currently in use in the energy industry. The company was acquired by Fjord Capital partners in 2012, when a new company - Estibio was then spun out, and BioGasol then raised €15 million, in part from Fjord Capital (€5 million).[71]

- **Glycom:** this DTU Spin-off company was established in 2005 with DTU IP. The company produces milk oligosaccharides identical to those in human milk which are added to some of the Nestlé baby formula products. The company's seed round was followed by two further rounds in 2011 and 2016 (total raised €2 million) and included a strategic investment from Nestle US (its corporate partner). Other investors include Danske Bank, PreSeed Ventures and Seed Capital (Denmark). The company's profits in 2017 were DKK 63 million (€ 8.5 million)[72].

- **Copenhagen Nanosystems** was established in 2016 as a spinout company from DTU Nanotech. It has developed a lab-on-a-chip technology that can be applied in the food industry. The company brought its products to market In one year, and although its is not yet profitable its revenues are approaching DKK 1 million (€133,000). The company accessed DTU supported facilities and equipment (DTU Danchip) enabling it to access resourced to develop its prototype and initial products at relatively low cost.

Venture Capital

The funding situation for DTU spin-off companies is relatively strong, with multiple options from DTU-owned funds and other external investors that have demonstrated their support for DTU Spin-offs (see 'Enterprise Support' above). The main actors are PreSeed Ventures and Seed Capital (Denmark). PreSeed is an innovation support organization owned by DTU which invests venture capital funds into companies on behalf of the state (up to €0.78 million as loan or equity)[73]. Seed Capital is the biggest Danish early-stage venture fund that invests up to €0.5 million in young technological companies but can follow its investment up to €10 million per company [74]. In addition, the landscape includes several consulting companies based within the DTU Science Park which assistance to high-tech companies that are seeking investment.

[71] see http://www.biogasol.dk/about-us
[72] See Glycom Annual Return: https://regnskaber.cvrapi.dk
[73] see: https://preseedventures.dk/our-story/
[74] see: https://seedcapital.dk

2.1.2. Case Study - Karolinska Institute

The Karolinska Institute (KI) is one of the leading universities in Sweden and it is regarded as having one of the best developed systems for commercializing research knowledge in Sweden [44]. KI is specialized in the field of human medicine, having been originally founded as a royal hospital, and its research and innovation activities fall predominantly within this industry sector. KI values its relationships with industry with generated €30.4 million in 2017 [75], and this is therefore a very important mechanism for direct technology transfer stemming from collaboration and industry 'pull'. Where IP and innovation arises outside of an industry collaboration or a research contract, KI commercializes this through a sophisticated system of both 'in-house' and external agency support, which is described below. The Swedish law that enshrine the 'professor privilege', where researchers have an automatic right to own their inventions, has influenced the way in which KI and other Swedish universities approach technology transfer (see Section 1.7 in this report).

The KI technology transfer and research commercialization system is comprised of five operational units, which are described below: KI Holding AB (KIHAB), is the commercial vehicle that holds interests in the private companies that are part of the system including KI Innovations AB, KI Housing AB and Karolinska Development AB (6.8% owner). KI stands out in its predominant use of the spin-off strategy; with 49 well-funded spin-offs in the period 2004-13.

The major elements in the KI innovation ecosystem are described below:

- The Unit for Bio-Entrepreneurship, which is responsible for education and research in innovation and entrepreneurship.
- The KI Innovation Office. This provides support to researchers and students in identifying and developing their commercially-interesting ideas and identifying tentative innovation partners. Ideas are passed on for commercial verification by KI Innovations AB (KIIAB). The Innovation Office is partly financed through government grants
- KI Innovations AB (KIIAB). The role of KIIAB is to verify research results ahead of commercialization and to facilitate the conversion of scientific discoveries and research results into valuable products and services. KIIAB services include patent and legal advice, business advice, seed funding and formation of spin-off companies, and portfolio management of KI's spin-offs.

[75] Karolinska Institute Annual Report, 2017.

- The KI Science Park (part of KI Housing AB). The KI Science Park which is responsible for providing incubator and science park facilities (office space, labs, equipment, etc.) for promising life science spin-offs.

Karolinska Development (KD), which is a life science investment company listed on the Stockholm-NASDAQ stock exchange. KIHAB has a minority shareholding in KD, which has an agreement with KI Innovation to have first right to invest in the most promising spin-offs. KD also has the ability to invest in other companies and it is not wholly reliant on KI for its pipeline of new investments.

The most visible element in KI's technology transfer ecosystem is Karolinska Development, in which KI has a minority shareholding. Karolinska Development went public in April 2011, bringing in €63 million on the Swedish Stock Exchange[76]. In 2017 KIIAB launched 9 spin out companies and according to the 2018 company report, KD currently has 10 companies in its portfolio with 8 in the clinical phase, and a portfolio valued at around 1 billion SEK (€100 million)[77].

2.1.3. Case Study - Vlaams Instituut voor Biotechnologie

Vlaams Instituut voor Biotechnologie (VIB), established in 1996, is a decentralized research institute that specializes in biotechnology research. VIB's departments, labs and research facilities are located within its partner universities throughout Flanders (Ghent University, the K.U. Leuven, the University of Antwerp and the Vrije Universiteit Brussel). it is a pure research institute and has no undergraduate students. VIB is funded by a significant investment from the Flemish Government, in return for which it is expected to generate high quality research (publications), and technology transfers (patents, licensing agreements, startup companies, etc.).

VIB is a leader in translational research and technology transfer. Its research programmes makes use of advanced molecular biological technologies to study the functioning of human cells, plants and microorganisms. The institute has achieved major breakthroughs in the field of cancer, immunology and inflammation, neurobiology, cardiovascular disease and plant systems biology. The technology transfer activities are focused around the useful applications of the research, such as diagnostics, medicines and agricultural applications.

VIB has created an extensive innovation ecosystem. This has been reviewed by Uecke et al.[78]. The main elements of this are described below:

[76] see: https://techtransfercentral.com/2011/07/13/karolinska-institutet-to-set-out-10-year-plan-after-taking-tto-public/
[77] Karolinska Development Annual Report 2018. https://www.karolinskadevelopment.com/sites/default/files/agm/Annual%20report%202018.pdf
[78] Effective Technology Transfer in Biotechnology: Best Practice Case Studies in Europe. 2014. edited by Uecke Oliver, De Cock Robin, Crispeels Thomas, Clarysse Bart. Imperial College press. p19.

Translational research programmes: this is the beginning the innovation process, VIB's programmes develop scientific discoveries such as potential dug targets diagnostic tests, new drugs or new agricultural molecules into the starting points for new technologies, by designing rigorous programmes that test utility and feasibility; at the mature end of the spectrum, these include clinical trials or field tests. In order to fund the increasing costs of these programmes the institute works with industry partners who license the technologies and make increasing financial and resource contributions to the programmes as they meet their milestones and become increasingly valuable. These programmes drive the requirement for licensees that may be existing companies or new venture-backed spin-offs. A good example of successful partnering with industry and licensing of VIB technology is the Universal Flu Vaccine programme. VIB partnered its technology in this area with Acambis (a UK company) who demonstrated the safety of the 'VIB vaccine' in a Phase I study. In 2009, Acambis was taken over by pharma giant Sanofi-Aventis, which continued the development of the vaccine.

Technology Transfer: This function is performed by VIB's Innovation & Business Team. the team is comprised of 12 full-time officers (with 6 yrs. experience) with a diversified background. 8 of them are experienced in the biotech industry (2 years) 1 person has a legal education. None of them is a certified licensing professional, or has a business PhD, or an MBA. All of them have a biotech-related master's degree and pursued a biotech-related PhD. When the team has grown rapidly, less experienced members are recruited that require training. VIB (not the TTO) has two in-house attorneys who support the TTO's legal demands.

The TTO team's initial activities are IP screening, which takes up approximately 30% of staff time. The relationships with staff appear to be less deferential than in other institutes, where TTO staff control the IP valorization pathway and process, this may be because VIB's constitution makes continued funding dependent on strong technology transfer performance. The formal processes include a record on invention (ROI), which may draw on a draft scientific paper, and continues with searches for prior art. The culmination of this phase is a decision on patentability. At VIB around half of the inventions are deemed strong enough to patent.

In parallel with patent filing, the TTO begins searching for potential licensees who will take on the IP costs; however, if licensees are not identified, VIB has sufficient budgets allocated to support patent applications and prosecution. VIB projects a very strong belief in the importance of its inventions to its potential licensees, and involves the research investigators in this dialogue wherever possible. The licensing process includes checks on the motivation and ability for licensees to invest sufficient resources to succeed (which is helped by the fact that VIB designs the development pathways and understands what is needed). Licenses are written to ensure that

licensees do not have the option to sit on the IP (e.g. to use it to block competition). The outputs of the VIB TTO (as published in 2014) are shown in Table 13, below.

Table 10. Technology transfer statistics of VIB

Technology transfer statistics of VIB	
Invention disclosures (2005-2010)	280
Patent applications (2005-2010)	125
Income generating licenses (2012)	71
LOA revenue (2012)*	€15,000,000
Spin-off portfolio (2012)	12
FTE employed in spin-offs (2012)	540
*** Including license income R&D collaboration income, service income, income from sale of shares, Etc.**	

The TTO statistics were partially updated in the 2017 VIB Annual report (published in 2018) which reported that its Innovation and Business unit, generated industrial income of €28.7 million, and established a new start-up company: Aelin Therapeutics, which raised €27 million in its "A" investment round. The report also noted cumulative industrial income (2013-1018) was €125 million, an average of €25 million per year - indicating significant growth since 2012 [79].

The VIB TTO also offers its services to external biotech research groups and provides structural support to the University of Hasselt, The University of Antwerp and the University of Ghent. The team also provides technology transfer services to international TTOs, and organizes formal training events, including its annual VIB Tech Transfer Course[80].

Business Support: The strong drive to transfer high quality R&D into society has led to VIB using spin-off companies as a viable alternative to a partnership with an existing commercial licensee. VIB has a mandate that allows this, and the funding is made available to pursue these options. This strategy it has the advantage of providing the institute with significant insurance that commercialization of its R&D assets will be fully explored, without deference to the internal strategies of large corporate partners.

In addition to the functions described above, the VIB TTO also supports its investigator/entrepreneurs through mentoring to developing their business plans, assist in the recruitment of external management, in designing the operational plans, in locating office space, in sourcing equipment and in searching for funding. In accomplishing this last goal, the TTO makes

[79] From VIB Annual Results 2017. see http://www.vib.be/en/news/Pages/VIB-presents-its-2017-annual-results-and-confirms-its-reputation-as-global-player.aspx
[80] see: https://eu-life.eu/event/vib-tech-transfer-course-2019

itself familiar with federal grants, foundations, accelerator funds and the like and develops good contacts with the venture capital community and other investors.

Spin offs and incubation. VIB has provided strong support for its spin-off companies throughout its history. It has developed two business incubators in Gent and Leuven (25,000 m2), and at the Ghent site (the Zwijnaarde Technology Park) the institute has established its 12,000 m2 Accelerator for companies that have grown beyond the incubation stage[81]. In order to resource these infrastructure developments, VIB has used its existing partnerships with universities (Ghent and KU Leuven) and real-estate investors amongst others. Although these facilities are open to non-VIB start-ups, the pipeline of companies created by VIB dominates the occupation of these spaces.

Examples of VIB spin-out success include Ablynx, Actobiotics and Multiplicom:

- **Ablynx:** In November 2001, Ablynx was established as a spin-off of VIB and the Free University of Brussels (VUB). Ablynx is focused on the discovery and development of Nanobodies, highly effective therapeutic proteins which that can be used in the development of drugs for the treatment of a wide range of human diseases including inflammation, hematology, oncology and respiratory diseases. Nanobodies disrupted the human therapeutic antibody market. Initial seed financing of €2 million was provided by Gimv, and the company completed its IPO in 2007. Gimv exited in 2013 with a return of €3.8 million. In January 2018, Ablynx were acquired by Sanofi for US$4.8 Billion.

- **Actobiotics (now Actogenix):** This company was established as a spin-off from VIB and the University of Ghent in June 2006, focused on the development and commercialization of ActoBiotics, a novel class of orally available biopharmaceuticals, designed to be safer and more effective than injectable equivalents. Gimv and Biotech Fonds Vlaanderen co-led the initial series-A funding round of €20 million. The company was sold to Intrexon Corporation in 2015 for $60 million. The sale provided a modest positive return to the founding investors

- **Multiplicom:** This company was founded in 2011 as a spin-off from VIB and the University of Antwerp. Multiplicom developed, manufactured, and commercialized molecular diagnostic kits for personalised medicine (including pregnancy). The company's seed round of €2 million was let by Gimv (and included VIB and University of Antwerp). Agilent Technologies bought the company for US$68 million in 2017 [82].

[81] see: http://www.bio-accelerator.com/en/home
[82] see: https://www.gimv.com/en/newsroom/pressrelease/diagnostics-company-multiplicom-be-acquired-agilent-technologies

Venture capital:

VIB was instrumental in founding the venture capital company, V-Bio Ventures in 2015, whose first fund has raised €76 million, including funds from the European Investment Fund (EIF)[83]. The company's stated goals are to find, build and finance young, innovative companies with ambitions in the life sciences arena. Although the fund can invest throughout Europe, V-Bio Ventures has an agreement with VIB for a 'proprietary deal flow', and its investments are therefore heavily biased towards VIB's business incubation pipeline [84]. Prior to the founding of V-Bio Ventures the regional seed capital VC fund, managed by Gimv was the major lead investor in VIB spin-off companies.

[83] Other investors include ARKimedes, Korys and KU Leuven, Gimv, SFPI-FPIM, BNP Paribas Fortis Private Equity and Ghent University. ARKimedes is an initiative of Participatie Maatschappij Vlaanderen NV and the Region of Flanders.
[84] See 'V-Bio ventures' website: https://v-bio.ventures/2015/11/19/first-closing/

2.2 The Features and Issues of International technology Transfer Systems.

Features of technology transfer systems that emerge from the national profiles and the international case studies have been considered and described below. These features have been selected based on their potential relevance to success.

1. Association with recognized research excellence

The three subjects of the international case studies are technology transfer systems that are attached to institutions that have globally and nationally recognized capabilities for research and are highly rated through a variety of benchmarks. It is likely that this recognition ensures that institutions attract and retain the highest caliber academics and researchers, who in turn generate high quality research outputs that form the pipelines of the respective TTOs. This association with excellence assures that the activities of researches (and their outputs) receive widespread attention in the media, and with potential industry partners, licensees and investors. The age of the institution does not appear to be a determining factor, in this respect. While the Karolinska Institute has a long history, the highly respected VIB was established in1996.

2. Attachment to large scale research assets

The leading TTOs are part of organizations that have significant research capabilities, in terms of uniqueness, scope and scale. Scale is usually the result of organic growth of the institution, but in the case of VIB, this has been achieved by consolidating research assets from various sources under a specific theme (biotechnology) and becoming a world-leader as a result. A functional interface between research and TTO can offer companies access not only to research outputs, but also to know-how and facilities that can be used to explore their own priorities and co-develop customized solutions to their challenges. The level of integration of the TTO with its research infrastructure can vary. All of the leading TTOs stratify its industry liaison activities into contract-based and IP-based, and at KI the contract research activities appear to be regarded quite separately from its technology transfer and IP commercialization activities.

3. Autonomy

There was considerable variety in the level of TTO autonomy exhibited in the systems that were studied. For instance the Israeli TTOs, while being largely owned by their parent universities and research institutes, work as independent companies with respect to raising investment to support their technology development programmes and spin-off companies, while VIB's TTO is centrally directed by the institute to develop programmes based on the perceived value of its research

discoveries. The model at KI is somewhat different, with an autonomous company (Karolinska Developments - KD) that has preferential access to KI IP (if the IP is not already subject to research contracts). It is notable that KD is not majority owned or controlled by KI, and includes non-KI technologies in its portfolio.

4. National strategic importance of Innovation and Technology Transfer

Strong TTO performances are backed by very strong national priorities and policies for innovation and related activities. For example, Israel generated the strongest national TTO performance (in terms of LOA income). In Israel, innovation has always been a high national priority, initially to support its agricultural industry and defence capabilities with medicine included more recently; government support is evident and widespread in both the public and the private sectors. VIB in Belgium is subject to both regional and national innovation policies; however, both appear to be aligned and very supportive, and the success of VIB is largely due to high levels of regional government investment and a permissive national strategy. Ireland has established its national innovation policy relatively recently, which has resulted in significant improvement in its national TTO performance. In Denmark the Government's Board for Research & Innovation ('Styrelsen for Forskning og Innovation') takes a very strong interest in innovation having established funds for IP protection and significant incubation infrastructure, along with Ireland, UK and Australia it also requires its supported institutions to provide annual performance returns. In Sweden, KI was initially more independent of government policy, due to the law assigning IP rights to individual inventors rather than the University. However, over time the government has developed strong national innovation policies, which the University benefits from, particularly in the area of entrepreneurship.

5. Toolkits

The agreements that underpin technology transfer between institutions and companies are a critical part of the process, and any issues with agreements can affect the speed of transfer or the likelihood of success for both sides. The UK government commissioned a suite of model template legal agreements with input from industry and academia, which have been adapted for use by Irelands national technology transfer organization KTI. In 2008 the Danish Government introduced a model IP contract toolkit for universities and industry. These toolkits are used by the leading TTOs to improve the technology transfer process, increasing transaction speed and reducing legal expenses.

6. Specialization

There is some degree of specialization in all three of the Case Studies, DTU is largely focused on engineering, KI on human medicine and VIB on biotechnology. It is also worth noting that the Government-funded research institutes of Switzerland and Ireland (which are specialized) appear to out-perform general universities with respect to average value of its LOAs. This suggests that TTOs that can focus on the outputs of specific research disciplines, or industry sectors are at an advantage. Staff of specialized TTOs will be able to maintain higher levels technical knowledge without needing to study new areas on a regular basis. This TTO staff specialization also helps to support good dialogue between TTO staff and researchers.

7. Financial Independence

The institutions that are associated with Successful TTOs work on very large budgets funded from government grants, other public sources, private income, private investment or their own reserves. These institutions have all prioritized technology transfer as an extremely important activity (in the case of VIB it is part of its constitution), and have the means to ensure that it is well-funded; however, the return from TTO activities in relation to overall budgets, or even industrial research contracts, are relatively insignificant (except for Israel). These TTOs are clearly not required to be financially self-sustaining, and therefore they have a high degree of stability, which undoubtedly improves staff quality and retention and provides freedom to support higher-risk technology transfer projects than would otherwise be possible

8. Entrepreneurship and spin-offs

Spin-off companies are a very important feature of successful TTOs, and all of the TTOs in the Case Studies have developed their own supporting infrastructure; however, the models are all different. Within the KI TTO system there are separate elements that conduct proof-of-concept work, and an independent development company that selects promising KI projects to develop and then raises venture capital investment. VIB selects technologies for commercialization and then either sources Industry partners or creates spin-offs, this is the most 'directed' model. DTU's spin-offs arise from its entrepreneurship programmes, led by investigators and students, and are then financed competitively through affiliated investment funds. The Israeli TTO's develop spin-offs and support them by raising significant venture capital, often from investors based in USA. The TTOs that have the most successful spin-off programs, regularly raise large amounts of investment for each (€5-50 million) which provide stability and sufficient runway to achieve high valuations. However, the overall returns to TTOs or their parent institutions from commercialization through spin-offs are relatively modest and the main motivation is to ensure that useful research outcomes can make a positive difference to relevant industries and ultimately to economies, which reflects well on the institutions from where the technologies arise.

9. Networked Ecosystems

Some (but not all) of the systems included in this work have developed features that extend the reach of their TTO activities beyond their own walls. The Danish hospitals innovation ecosystem features a distributed network of technology transfer expertise, which was created with support from Copenhagen University in order to quickly establish 'on the ground' support for multiple hospitals in a wide geographic area. This system appears to be performing well, and in a very short space of time has led to hospitals generating a significant proportion of the country's patent applications, LOA's and spin-off companies. The KI system is also developing a network approach in response to national government encouragement; through this approach, external institutions within the same region can participate in KI's innovation support systems, providing immediate access to a world-class TTO infrastructure without requiring a long and expensive process of building it from scratch. VIB also makes its TTO expertise available to external organizations, through private consultation and workshops.

Chapter 3. Portuguese Technology Transfer

In the first part of this study 'Analysis of the Activities of Portuguese TTOs 2015-2016' ('ANI TTO Survey 2017'), the data generated from the survey of 85 Portuguese TTOs was analyzed and major trends were observed. The findings from this analysis and the subsequent comparative analysis of TTO activities from Portugal and a range of close comparator countries is outlined below in section 3.1. This is followed by summaries of discussions that were held with a selection of TTOs (3.2) and companies (3.3) with the purpose of understanding how IP-active TTOs operate, and how Portuguese industry perceives the functionality of the national TTO infrastructure. Relevant features from the analysis and these discussions were then drawn out and presented in the following Chapter 4 as features of and issues with Portuguese TTO infrastructure, with the objective of providing input for strategies for strengthening and improvement.

3.1 Features of Portuguese Technology Transfer

The first part of this study 'Analysis of the Activities of Portuguese TTOs 2015-2016' ('ANI TTO Survey 2017') revealed significant detail that can be used to describe the Typical office. The average Portuguese TTO is 11 years old, has 9.5 personnel that is relatively well educated, and qualified to deal with technologies derived from Natural Sciences and Engineering research activities; however, the majority of staff have less than 3 years' experience in technology transfer. TTO's file an average of 6 patents per year, but more than 50% of the active Portuguese patent portfolio is held by only 3 institutions.

TTO's make an average of 3.5 LOAs per year 80% of which are with Portuguese companies, most of which are small companies (but not Spin-offs) Only 72% of TTOs have the capacity to support IP licensing, the income from which which accounts for around 4% of the average TTO budget. Only 27% of TTOs receive royalties. 55% of all LOAs are made by only 5 TTOs, who generate 70% of the LOA income. Around 40% of TTOs claim that their LOAs have resulted in profitable products. TTOs enter into 914 research contracts with companies each year (and their institutions probably execute more agreement of this type that their TTOs do not have sight of).

TTOs are responsible for spinning off 370 new companies per year, of which only 8% are owned by the parent institution (i.e. the vast majority are independent, and probably owned and operated by students and/or staff, but may have executed an LOA). These spin-offs employed a total of 8343 people (6 per company) and had an turnover of €250 million (although only partial data was available from TTOs). The majority of these spin-offs are in the ICT sector.

The comparative data for technology transfer performance described in section 1.10 above indicates that Portugal is quite different from the other comparator countries with respect to the

number of 'active' TTOs in its infrastructure and the number of spin-off companies it generates annually. The number of research contracts reported are a little lower than in other countries. Patenting and licencing activity are relatively normal and income from licensing is comparable to its cohort of comparable countries. Taking the available data at face value, it appears the Portugal has created a much more extensive network of TTOs than the other countries, and that it chooses the spin-out route for commercializing IP much more frequently. Unfortunately, detailed and verifiable data is not available to describe the value that spin-off companies represent to Portuguese TTOs or the Portuguese economy.

The data analysis in the 'ANI TTO Survey 2017' indicates that TTO activities such as patenting and patent licensing are highly concentrated activities with only a very small number of TTOs being responsible for the majority of the activity; however contract research activity and spin-off company formation are much more distributed, indicating that Portuguese TTOs could be classed as 'IP active' TTOs (minority) or non-IP Active TTOs (majority). The reasons for these differences are not clear from the data; however, it is likely that the majority 'non-IP Active' offices lack the necessary IP-qualified staff, appropriate IP budgets and IP marketing expertise. IP may also be an unnecessary complication for TTOs that are focused on delivering contract research with commercial partners that are not seeking IP and do not want their research partners to hold IP that could block their commercial plans. Another factor may be that non-IP active TTOs have a local commercial focus and do not perceive a need to establish IP that would have a national or international market.

3.2 Feedback from Selected Portuguese TTOs

A variety of Portuguese TTOs were selected from those that participated in the ANI survey, and requested to provide their experiences, comments and options that relate to the way in which they approach their technology transfer activities, and their relationships with the infrastructure in Portugal. The main goal was to understand the current features of the Portuguese technology transfer system that could have a bearing on any new strategic directions in this field, as will be discussed in Part 3 of the work.

The TTOs that were contacted included the leaders in TTO performance, as reported in the ANI 2017 TTO Survey. These were deliberately included provide a range of TTO types and to ensure that the experiences of some of the most active TTOs could be included in this evaluation.

The TTO's were requested to prove information relating to its operations and progress with projects, including: the structure of the support teams; the nature of the support provided; the perceived value of the work to the 'host' institute (IP/technology owner), and to the commercial

partner (IP/technology user); and, the specific and systemic factors that both allow and prevent success.

The responding offices were invited to provide written feedback and to discuss their experiences with 2Bio via telephone calls or video conferencing. In this way, objective information was gathered, along with the contextual and qualitative information relating to the specific examples that were discussed, and the general opinions with respect to the technology transfer system in Portugal. Detailed responses were obtained from four Portuguese TTOs. The answers to the questions and the follow-up discussions were collated, and the relevant features of the local TTO infrastructure, practices, advantages and challenges were summarized and are shown below.

Detailed responses were received from the majority of TTOs that were contacted. The Offices that responded (and their relative positions with respect to licencing income in the ANI TTO survey 2017) were: TecMinho (3), University of Porto Innovation Office (4), I3S Research & Innovation Unit (1), INESC TEC Technology Licensing Office (14), and Instituto de Telecomunicações TTO (6).

TecMinho

TecMinho is a private not-for-profit association, founded in 1990 as an interface for the University of Minho (UMinho). It is comprised of Technology Transfer, Continuing Training and Finance and Administration departments and the main focus is on partnering with industry, commercializing R&D outputs and supporting entrepreneurship. The Technology Transfer Office is led by its Director, Dr. Marta Catarino (the respondent), and it is organized into: the IP unit with a coordinator, IP expert and IP admin; the commercialization Unit, with a coordinator, scouting expert, 2 project managers and 2 industry liaisons; and, the Entrepreneurship Unit with a coordinator, and 2 project managers. A total of 13 positions.

Operations: The partnering activities are directed towards establishing R&D partnerships that develop new products and services (suggested by industry); the associated activities are technology marketing, company audits, project management, funding (grants) and IP management. Commercializing is focused on the University's own IP assets; the associated activities are technology scouting, IP protection and management, early stage technology screening and evaluation, technology marketing, mentoring researchers and negotiating agreements. Entrepreneurship is directed towards launching of spin-off companies; the associated activities are identifying business ideas, developing an entrepreneur's potential, developing and managing the spin-off brand and introductions to financial networks.

IP: The university retains the ownership of the IP (and the revenues). As noted above, the TTO manages the entire process for IP protection from invention disclosure to patent granting and down-stream activities, including negotiating with potential licensees.

TecMinho Success

The TTO successfully licensed a group of 3 patents to a multinational chemicals company, the IP being related to chemistry and textile engineering technology. The Patents were the result of research performed at the Textile Engineering Department of the University, external companies were hired for technology validation work and TecMinho was careful to ensure that the IP ownership rights were not diluted by this. The Inventors were the principal investigator and 2 PhD students. The TTO protected the IP, provided support for the spin-off creation and access to relevant funding. Further support included marketing the technology nationally and internationally, through industry fairs, brokerage events and direct contacts, support for the negotiations with investors in the spin-off (legal and business), and support for negotiations with the multinational company that ultimately acquired the patents from the spin-off. The licensing deal provided significant revenues and the licensee developed a new business unit (based in Portugal) which employs 11 people. The commercialization project also led to additional R&D contracts for the University and valuable experience for the TTO staff.

The main factors that drive successful technology transfer at TecMinho are the motivation and commitment of the researchers that are involved, therefore ensuring that they are motivated and incentivized (not only financially) is crucial. Other factors that TecMinho considers to be important are: having a clear IP policy which is well supported through administrative functions; access to adequate PoC funding; and strong TTO staff skills.

Unsuccessful project features

TechMinho described a MedTech project where efforts to achieve a licence to the IP were unsuccessful. The immediate factors involved were that the potential licensee considered the technology on offer to be insufficiently developed and therefore too risky. The company expected the University to perform the additional development work it believed was necessary; however, no funding was available to achieve this. Once the licence negotiations failed, the patenting costs were too high to be supported by the University. The TTO recognized that limited staff resources prevented additional efforts to identify and secure other commercial licensees in time. The experience was seen as valuable learning opportunity for the TTO.

Further Relevant TecMinho Comments

The TenMinho TTO derives significant value from opportunities for its staff to update their skills and exchange best practices with colleagues in Europe and beyond. Their participation in professional development activities and events such as those organized by ASTP and visits to

international innovation ecosystems allow the improvement of skills and the widening and strengthening of the network of contacts.

Proof of concept (PoC) funding is essential to allow technology validation, de-risking, and access to follow-up funding. UMinho had a successful PoC fund, iProof20, which was managed directly by TecMinho. With a maximum investment of 20K€ per project, 6 R&D results from UMinho were significantly developed towards the market. 1 spin-off was created, 5 patents were submitted.

University of Porto Innovation Office

The University of Porto Innovation Office is responsible for technology transfer and other related activities at the University. This function was established in 2004 and the University's current framework on IP regulations was established in 2005. The innovation team in Porto is composed of 8.5 FTE, of which 3 FTE are dedicated to TTO and the remaining 5.5 FTE are split between the TTO and other activities such as entrepreneurship support. All team members are capable of dealing with IP issues, while 3 team members are specialized with respect to three major disciplines (Life Sciences, ICT and engineering), and 1.5 FTE manages the interface between research and companies. The team can leverage additional support from up to 4 PhD students on a part-time basis for project evaluation work.

Operations: The Team works predominantly on IP asset management and entrepreneurship. Support is provided for initiating industrial research contracts; however, the faculties lead on this work, and therefore take autonomous decisions on the IP associated with research contracts. The role of excellent research in TTO success is well understood by the TTO, which recognizes a small group of highly regarded researchers that are also 'serial innovators' within its academic staff and monitors them closely. The Innovation Office participates in multiple industry networks. The university has formed "The Circle" a club of its spin-off companies that promotes networking and exchange of ideas; there are also well-developed links with local SMEs and sector-based clusters that coalesce around university research expertise. The TTO has been successful in retaining its senior staff (beyond 5 years).

IP: The university is currently managing a portfolio of 230 patents and has 22 active licences that are generating income. Patents that are not exploited are dropped from the portfolio. The team uses external professional support to manage patents (patent attorneys) and also for associated activities such as communications and networking events. There are plans to increase the patent budget, which should increase the flow of new IP-based projects (currently 20 projects are supported). Around two thirds of patent licences are issued to spin-off companies. The TTO has occasionally used technology brokers to market their IP, with disappointing results.

U Porto Success

The company Veniam was founded on IP created by University of Porto Professor João Barros in 2012. The company is developing IoT type technology to allow data transfer from, and software distribution to, subscriber vehicles. the company has offices in both Portugal and USA and has raised $30M in venture capital. The company now employs around 90 people and is operating vehicle networks in international locations including Porto, New York, and Singapore. The University derives income from the patents it has licensed to Veniam. The qualities of the company's founder are perceived to be the major factor that influenced the success of this technology transfer. When the company was founded, Prof. Barros had already built an impressive academic career in Porto, he was well-networked with colleagues in technology centers in the USA and he had determination and a clear vision for commercializing the technology.

An additional success factor for technology transfer at U Porto are perceived to be strong POC programmes, which support valuable technology development prior to spin-off company formation.

Further Relevant U Porto Comments

Successful technology transfer activities have resulted in U Porto graduates gaining valuable experience with spin-off companies and securing high-value employment. This activity may also be a factor in attracting new student applications; however, this has not been studied to date.

Previously the TTO has participated in programmes to support its staff training and skills including internships and workshops; however, recruiting skilled and experienced staff can be challenging.

University of Porto does not currently take an equity stake in its spin-off companies; however, plans to enable this could increase the long-term value of technology transfer activities to the university.

The split responsibilities for U Porto IP between faculties and the Innovation team may create variability in the fate of 'foreground' IP that is generated in collaborations with industry. standard terms for university agreements involving IP could help to create certainty and more equitable dealing with respect to the University's IP.

I3S- Research and Innovation Unit

I3S was formally established in 2013, as the result of amalgamation 3 major research institutes (IBMC, IPATIMUP and INEB), headed by the University of Porto. The TTO activities were also merged and became part of the I3S Research and Innovation Unit. A total of 8 staff are included as the Research and Innovation Unit team. Dr. Hugo Prazeres (HP) leads the team

Operations. HP takes responsibility for IP management and commercialization, and a range of innovation and entrepreneurial functions. The other team members cover functions such as contract research (including sponsored clinical research), industry collaboration, grant applications project management and contract management. The team does not include in-house legal expertise for IP, this activity is outsourced to external professionals on a case-by-case basis. The I3S TTO has demonstrated expertise with technologies that have clinical technologies including diagnostics.

I3S Success

A new diagnostic technology was developed from scientific research that was entirely derived from the 'parent' research organization. The TTO supported the POC, build contact with potential end-users, provided IP support, support to licencing IP to the spin-off; legal support to the company launch; located company space; conducted market research, prepared a business plan; raised investment, procured advice on regulatory issues and CE marking; commercialization planning and operation, setting-up a distributors network; recruiting for an Advisory Board with clinical expertise, commercial partner search, support in negotiation of deals, company management follow-up. The TTO negotiated a deal which provided 'up front' revenues and a multi-year royalty. Additional value was obtained through research contracts to the parent Institute. The technology provided the licensee company with its leading commercial product and was therefore the entire foundation of its current value proposition.

I3S success factors

The most important factor is the scientific excellence of the research and researchers that underpin a new technology. Other important issues are the feasibility of realizing the development of a product or service that is competitive and that can generate a sustainable commercial return (and it is therefore important to complete a competent market evaluation at an early stage to confirm this). It is important to select a commercialization team (spin-out team) that is competent to deliver the exploitation plans and has commitment, dedication, passion and proactivity. Inclusion of appropriate clinical expertise (such as through an advisory board) is important, as is the inclusion of people with previous business experience.

Unsuccessful Project features.

Outline details were provided of project failed to attract a licensee due to the team not including clinical advisory expertise. The technology package was not perceived as being sufficiently developed and specifically there was a lack of clinical evaluation data (resources were unavailable to achieve this).

Further Relevant I3S Comments

Lack of funding that is dedicated to clinical proof of concept studies limits the ability to develop and commercialize technologies with clinical applications, as the significant level of funding necessary to support this type of project is beyond the means of the institute and University and is not easily available from industry partners in the national innovation ecosystem

INESC TEC

The Institute for Systems and Computer Engineering, Technology and Science (INESC TEC) is a research & development institute located on the campus of the Faculty of Engineering of the University of Porto. The Institute's TTO was established in 2013. The Office is composed of 3 people led by Dr. Catarina Maia (CM). The main objective is to exploit the research output of the Institute. The team is supported with access to other INESC TEC staff including the institute's 4 legal professionals that have responsibility for contracts and data protection functions. The TTO has also worked with independent technology brokers that have identified potential licensees. The team has developed specialist expertise on electronics technologies and software licensing (including open-source licenses).

Operations: The major team activities include scouting and gathering information on research that has potential commercial applications, providing IP input for grant applications, and overseeing the IP aspects of research contracts with companies. The team screens the research for over 600 researcher FTEs in 12 research units, monitoring this extensive group is made easier by having automatic notice of research publications, and knowledge of the IP/innovation hotspots, which can make monitoring more effective through targeting. Other activities such as being involved in IP planning as part of institutional grant applications provides foresight on downstream IP generation and commercialization strategies. The institute uses standardized agreements for contract research, which assign the majority of new IP to the partner company, the TTO supports appropriate technology transfer; where contract values are low INESC TEC will retain the IP rights or may offer an option on the foreground IP. Where IP arises that is not already subject to an agreement, the team evaluates and develops an IP and commercialization strategy, and is actively involved in securing a commercial partner/licensee. The TTO team take great care to establish and maintain good relationships with their research community, and in particular to make regular contact with the key research groups and 'serial' innovators amongst the institute's staff. The Team is more able to focus on background research and IP aspects of their projects due to the

provision of in-house legal support (external to the team) that takes on the contractual work that is generated by the TTO.

IP: the majority of IP generated by the Institute is subject the research contracts, where the partner paying for research has negotiated the IP rights as part of the process. Since the office was established its patent portfolio has grown from 5 patents to more than 180. For its patent applications, The TTO can hire specialist patent writers and will work with a range of patent attorneys, chosen for their appropriate skill sets (e.g. very important for framing EU software patents), including those based in other countries. The patenting strategy includes international filings to ensure widespread coverage of the most valuable IP.

INESC TEC comments

The TTO has developed expertise in software licensing and commercialization but does not currently have sufficient opportunities to share this expertise widely within the Portuguese environment.

MC has developed template agreements for commercialization activities, which were based on the 'Lambert Toolkit' from the UK. Using these templates has proved to be very beneficial.

Instituto de Telecomunicações TTO

The technology transfer office of the Instituto de Telecomunicações was established very recently, being formally organized in July 2019. The TTO is composed of a small team of three people, that is led by the General Director, Marcelino Pousa. The main functions of the office are: to register and value intellectual property; to increase the R&D contracts with companies; and to Increase the number of EU projects in consortium. One team member is assigned to each of these three functions but work cooperatively to meet the needs of the research community in the institute. The TTO has capability to support IP but is not mandated to create spin-off companies.

Operations: This small TTO performs evaluations of the institutes technologies to understand their technological and commercial feasibility and their potential commercial value. The team seeks out companies that are potential customers, or partners that can further develop the technology and take it to the market.

IP: The TTO works primarily to establish research projects with companies which result in contract income and which result in the company retaining the IP generated though the contract. This, combined with the fact that software is not as easily patented as other technologies, results in

the institute having a very small patent portfolio. The revenues received from licences is relatively small and is not a major driving force behind the activities of this TTO.

IT Success

The TTO has provided an example of a successful IP licensing project which pre-dates the establishment of the TTO and is related to networks and protocols in the field of information and communications technology. The Institute provided technological input in the creation of a start-up company, which resulted in a licence to the technology it used. The resulting startup currently pays royalties to IT in respect of this license, the quantum of which is expected to increase as the company grows. As a result of this initial IP agreement, The Institute established a further 2 R&D projects with the company

The TTO considers the most influential factors for success to be (in order of importance): the reputation of the innovator/researcher; commercial sponsorship; the quality of the research; a strong internal POC programme; good networks; and a strong IP protection strategy.

Unsuccessful project features

The IT TTO provided the example of an information and communications technology project where the technology in question did not achieve a commercial outcome. The TTO failed to find a suitable licensee and attributed this to the lack of relevant experience and expertise of the staff who were involved. As a response to this the institute created a formal TTO, which has improved the capacity on the institute to evaluate technologies and seek commercial partners.

Further Relevant IT Comment.

The TTO is currently operating with the minimum complements of staff to achieve meet its demands, further capacity may be added by contracting external expertise to perform functions such as market research.

General TTO comments

During the interviews and the information gathering activities for this report, TTO's provided general comments and observations on issues within their organizations and elsewhere in Portugal. These comments have been included below, but without attribution, to prevent any unintended consequences to the respective TTOs and staff:

TTO performance measures rely on 'Traditional' activity data such as patent licencing data, but the value that an institute's own innovators place on its TTO should also be taken into account.

The TTO's business model is based on achieving sustainable income, and failure here can affect morale and ability to recruit and retain staff. In reality other benefits are derived from TTO and recognition (and reward) for these benefits could help to motivate and stabilize TTO workforces.

University inventors can have significant influence over the patent licensing process to their own spin-off companies, and can successfully reduce the size of licence payments that the company is required to pay, which ultimately reduces the revenue to the University and the perceived 'performance' of the TTO.

TTOs perceive an underfunding of their operations. This results in prioritization of activities that are more likely to generate revenues, rather than those that improve technology transfer rates. For instance, initiatives such as entrepreneurship programmes may fund TTO staff positions but can divert activity away from the core tasks of the operation.

TTOs suffer from a lack of 'standardized' terms for IP agreements, including inventor's rights and licensing fees. This can create uncertainty and unfairness, and de-motivate all parties (e.g. companies pushing for short term gains (low or zero licence fees) can destabilize the income stream and performance criteria for the TTO / University.

The opportunities for TTO networking in Portugal are relatively limited, which inhibits sharing of experiences, good practices, and community approaches to solve systemic challenges. Building more effective connections with industry associations could be mutually beneficial.

Currently, TTO networks in Portugal are not evident. There is no annual conference other than satellite events.

Newer initiatives such as collaborative laboratories (colabs) are creating new interfaces between research and industry that are expected to generate new IP. The management of IP within these initiatives can be opaque and therefore out of the reach of the university TTO to offer support.

Recruitment of TTO staff is problematic, the experience level of applicants is low. This is compounded by the lack of formal TTO training opportunities that are available in Portugal.

TTOs have limited capacity to offer experience-based training opportunities, and limited training budgets that restrict access to more formal skills-based training.

A strong national IP and technology transfer policy would be beneficial to Portuguese TTOs, such as the model developed in Ireland which provides centralized TTO support through the KTI.

In Portugal the concept of IP in research is still relatively new and the culture in this area is not well developed. As a result of this, failures with respect to IP commercialization or technology transfer do not have the resonance or impact that might otherwise be expected, and therefore there is often no pressure from researchers for their TTOs to perform well in this area.

Companies that negotiate with our TTO for IP rights (especially SMEs) frequently have no internal capacity to manage this process, due to an absence of qualified and experienced staff. Companies are unprepared for the cost of appointing professional legal support and may use legal practitioners that have no specific qualification or experience with IP.

TTOs experiences with local companies is often very poor, due to the company's lack of understanding of the nature and value of IP. In addition to applying resource to improve the understanding of IP in companies, more efforts to promote Portuguese IP internationally may result in greater technology transfer rates and more value for Portuguese research organizations

The older and more established TTOs tend to have a less flexible approach to technology transfer than newer offices and must navigate more layers of 'transactional process' in order to complete technology transfers.

3.3 Feedback from Portuguese Industry

Interviews were conducted with representatives of companies that have worked closely with Portuguese TTOs. These contacts had extensive experience working in knowledge-based companies at various levels, including CEO positions in new and established companies, which required them to negotiate with TTOs and research groups to establish commercial relationships and agreements.

The interviews were structured around their experiences of working with TTOs in Portugal, and their view of the TTO performance, TTO processes, and TTO culture. The most significant observations are summarized below. The purpose of documenting this information is to illustrate the company viewpoint of TTO activity; however, due to the subjective nature of the information, the names of the contacts and the names of the TTOs involved are not shown.

TTO Performance

There was general agreement that the competence of Portuguese TTOs has been steadily improving over the years, with rapid improvements coinciding with national initiatives and government investment in infrastructure. Prior to 2005 TTO infrastructure was basic and companies experienced very little support for technology transfer. Good TTO performance has been experienced with only a small minority of offices. TTOs are sometimes specialised, and are therefore more competent with some technology areas than others - resulting in offices succeeding in commercialising only a proportion of the research areas of the parent institution. Timeframes to complete licence agreements are often unacceptably long and agreements may not be completed due to this, or due to other complications such as failure to agree on license fees or other terms. There is scope for general improvement in the necessary skill sets both within TTOs and within companies in Portugal.

TTO Processes

The TTO activity that companies found most valuable was making connections with academic research groups that were potential partners for them. This activity leads to collaborative research, and research contracts, generating income for the R&D partner and new IP for both partners, which should have high industry relevance. Companies find it very difficult to make these connections. Some TTOs are very responsive and effective in supporting this function, but many do not engage or are not in a position to make these connections.

Other valuable activities for companies include sourcing existing IP and licensing IP through TTOs. TTOs may advertise their IP portfolios to industry networks, however companies do not believe that these networks are sufficiently developed and that they do not reach into the majority of companies in Portugal. IP licensing is dependent on both the TTO and the company conducting preliminary discussions and investigations and in agreeing acceptable terms. This process requires processes such as NDA and MTA agreements to be made, and 'heads of agreements' (draft outline terms) to be considered. Companies experienced some deficiencies in these processes, but acknowledged that there are gaps in skills and knowledge in both TTOs and companies in this respect.

Another difficulty that companies experienced with the process of licencing IP was the complication of IP ownership; examples were given of companies that were unable to access or licence IP due to prior claims on IP from other companies that had sponsored the connected research, but were unwilling or unable to exploit the IP themselves; other examples were given of IP being unavailable to companies due to groups (such as VC investors) having a 'first right of refusal'. Companies also felt that the licensing terms put forward by TTOs could be unrealistic and may be influenced by models that have been developed in other countries, such as the USA, where different factors are in operation.

TTO Culture

The development of the TTO infrastructure in Portugal has introduced a more positive attitude of academia to industry and better relationships with companies that wish to work with academic research groups and use university IP. There is still some work to do to spread this positive attitude to more researchers and TTO staff. Very positive examples were provided by companies where TTO staff have made strong efforts to create synergy between academics and companies, and have dealt with the formal side of the relationship in a very professional way. Currently it is only a minority of TTOs and a minority of the staff within TTOs that have such a proactive and flexible approach.

Companies perceived that the majority of TTO staff they had contact with lacked motivation to achieve effective relationships with industry. Staff were often relatively new to the technology transfer field and therefore lacked experience and strong networks within academia and industry, resulting in a lack of engagement and a lack of 'deal flow' and little success (as measured by the metrics of licence income). Companies felt that not enough weight was given by Universities and TTOs to the achievements of establishing productive relationships with industry partners, and that

a change in this direction could improve the motivation of TTO staff, increase staff retention and build more experience.

Summary of issues identified by the interviewees:

- TTOs in Portugal have big differences in levels of competence and only a small number of TTOs work competently with industry.

- The competence of TTO staff can be highly specialized and may not cover the whole spectrum of research found in the host institution.

- TTO staff may lack adequate incentives or motivation, and do not remain in position for a sufficient length of time. TTO staff therefore have limited opportunities to acquire necessary experience.

- TTOs and their parent institutions should provide more recognition for successful collaborations with industry, rather than the narrow outcome of licensing income.

- Competence of TTOs is improving - presumably as more staff choose this work as a career and become more skilled.

- Contractual negotiations between TTOs and companies are problematic and could be a significant cause technology transfer failure.

- The current levels of engagement and networking between TTOs and companies is inadequate, stronger and bigger networks are needed.

- There may be conflicts of interest where TTOs establish relationships with investors or industry, which may limit access to other potential collaborators or licensees.

Chapter 4. Features of Technology Transfer in Portugal and SWOT Analysis

The work in the previous 2Bio report 'Analysis of the Activities of Portuguese TTOs 2015-2016' (the first 2Bio Report) has analyzed a large data set on Portuguese TTO performance and drawn out the main features from that analysis. Further work documented in this second 2Bio report has obtained 2016 TTO performance data from a cohort of close comparator countries and compared this at a national level with the 2016 TTO performance data from Portugal (Chapter 1 of this report); further work has analyzed the performance and operational features of a selected group of leading TTOs in those countries (Chapter 2). Finally, a group of Portuguese TTOs and industrialists have been interviewed to understand the scope and practical experiences of technology transfer from both sides of the table (Chapter 3). The findings from all of this work have been reviewed. The key features of Portuguese TTO and the key issues that are currently affecting this sector, that have emerged from the review are listed and described below. The intent is that these points will be considered when determining new strategy for strengthening and improving TTO activities in Portugal.

4.1 Key Features of the data analysis for Portugal

Office Structure- Portugal has considerably more TTOs than any comparator country. The average Portuguese TTO is relatively young (founded in 2006), has 9.5 staff, who are well educated but have less than 3 years of experience in TTOs, and who have a high rate of turnover.

Finances- The TTO median annual budget is approximately €150,000 (mean €1 million). More than 75% of TTOs receive no income from LOAs. 70% of all LOA income is generated by the top 5 TTOs. The concentration of licencing activity in a very small number of offices is consistent with the pattern of LOA income generation in comparator countries.

Research Contracts- Portuguese TTOs execute 914 research contracts with companies, which is considerably lower than the number in comparator countries, although this may be an underestimate as Institutions frequently enter into this type of contract without TTO involvement. Research contracts typically assign the arising IP rights to the company.

LOAs- The total annual number of LOAs executed by Portuguese TTOs is similar to comparator countries, as is the total income generated (although Portuguese income is at the low end of the

range). LOA income performance for leading TTOs in Portugal falls well short of leading comparator institutions such as DTU in Denmark and VIB in Belgium

Spin-offs- Portugal generates a relatively high number of small spin-off companies. Spin-offs from some leading comparator TTOs are done in smaller numbers, at a much greater operational scale and with much higher levels of investment. Spinning-off is a strategic goal of most Portuguese TTOs, supported by well-funded entrepreneurship programmes. These spin-offs are largely independent of institutions and TTOs (i.e. the institutions do not typically have equity in the companies); spin-offs may have a combined annual turnover in excess of €250 million. It is unclear what the typical IP relationship is between Portuguese institutions and 'their' spin-off companies.

4.2 Key Comments and issues from TTOs and Industry

Excellence- Research excellence and good relations between research leaders / innovators and competent TTO staff are recognized as being of fundamental importance to the success of technology transfer.

Integration- The leading TTOs in Portugal are not sufficiently integrated into Institutional strategy and governance structures to enable comprehensive cooperation from all research staff, and to enforce adherence to technology practices that are in the best interests of both the institution and the researchers (e.g. oversight of all research contracts with IP elements, and fairer treatment of institutional IP and know-how when spinning-off companies).

PoC- Proof of concept funding to demonstrate technical feasibility of inventions is perceived to be a significant gap in the Portuguese Innovation / Entrepreneur landscape.

Licensing- Technology licensing to companies (that are not in a contract, and are not spin-off companies) is the least common route for commercializing IP, and most TTOs can find this activity challenging for multiple reasons that may include under resourcing, lack of opportunity, and unfamiliarity with the licensing process. Companies perceive IP licensing to be difficult and bureaucratic and recognize that there are insufficient IP skills within most companies to manage the process competently.

Training- All the responding TTOs highlighted the problems of recruiting competent professional technology transfer practitioners in Portugal, and the lack of resources and opportunities for training new and existing staff to improve skill levels. Companies perceive TTO skill levels vary greatly between offices and may avoid offices where skills are thought to be lacking.

Measurement- The most common and 'objective' measure that is used to assess TTO performance is licence income generation (LOA); however this measure may be misleading for Portuguese TTOs, with some offices underachieving due to 'friendly' license terms for research customers, spin-off companies and small SMEs. Institutions may also define licence income in different ways, which further affects the reliability of this measure as an indicator. The lack of institutional control of spin-off companies (through equity) may result in an under-reporting of technology transfer outcomes, as companies have no incentives to provide follow-up data.

TTO Networking- The majority of responding TTOs were concerned that there are few opportunities to network with fellow TTO professionals in Portugal at a National level (e.g. through regular TTO conferences), which limits the ability to disseminate best practices, develop collaborations and gather useful information and contacts.

Industry / Research Interface- Companies are dissatisfied with their ability to make contact with Portuguese researchers and to access technologies that meet their needs. This currently relies on private connections or highly localized networks, as there is no national-scale network or exchange where both sides can make contact with ease.

Standardization- Negotiations with companies are complicated by lack of useful examples to guide the process, lack of IP savvy within licensee companies and lack of contractual and negotiation skills on both sides of the table. At least one TTO has addressed this problem by creating a set of 'standardized' template agreements as starting points in contract discussions.

4.3 SWOT Analysis

Based on the analysis of data and feedback in this report, related to technology transfer in Portugal, and with reference to the comparisons with Portugal's international peer group, A SWOT analysis was carried out. The analysis identifies strengths, weaknesses, opportunities and threats for technology transfer in Portugal. these are listed below and summarized in Figure 1 (pág. 111).

Strengths:

- Portugal has a developed research system that is generating a significant IP portfolio.
- The volumes of LOAs generated by Portuguese TTOs is comparable to its peer group.
- Portugal has a widespread network of TTOs, providing broad coverage of the national research portfolio.
- The Portuguese TTO work-force is well-educated.
- TTO staff have academic backgrounds, generally good relationships (understanding) with academic innovators.
- There are identifiable centers of good TT, and TTO staff performance, and clear evidence that success is possible.
- New company formation is very frequent in Portugal, demonstrating few inhibitors of this process.
- Academic innovators are willing to support technology transfer into Portuguese companies, and also to get involved with spin-off companies.
- Portuguese TTOs are committed to supporting partnering companies via multiple strategies.
- Performance data has been obtained from 'active' TTOs, which is more detailed than data available in most other countries and permits useful evaluation.

Weaknesses:

- Resources are spread out over a very large number of TTOs, but only a small number of TTOs have strong LOA activity.
- There is likely to be duplication of TTO functions in most geographical areas.
- Most TTOs have very little experience of negotiating successful LOAs.
- Portugal has a high rate of TTO staff turnover (low rate of retention).
- Specific skills are generally lacking, and staff training is a low priority.

- Companies complain of protracted IP negotiations with TTOs.
- TTOs have irregular access to 'proof of concept' funding to develop value in IP.
- Companies generally lack necessary experience or resources for good IP management
- Networking opportunities for TTOs are inadequate.
- TTO-company networks are inadequate.
- Performance measurement criteria are mis-aligned and potentially de-motivating.
- The volume of TTO commercial research contracts in Portugal is lower than in the peer group.
- Income generated from LOAs is modest.
- Arrangements for IP ownership in collaborations or research contracts can be very loose.
- TTOs may not have oversight on all of the technology transfer activities that occur in their institutions.
- Data on 'downstream' economic value generation by TTOs is not generally available.

Opportunities:

- Introduction of a new technology transfer network in Portugal could have significant benefits if it can nurture good TTO practice, support training, toolkits and experience sharing and provide an effective and attractive interface between institutions and companies that are seeking technology support.

- Some consolidation of the existing TTOs could result in multiple advantages: increasing the average size of TTOs will improve capacity for diverse functions, allow more specialized expertise (such as legal) and opportunities for 'in-house' training.

- Coalescing similar TTO activities around existing centers of expertise (such as software licensing or clinical regulations) could improve national availability of these skills.

- A more robust and transparent system of technology transfer data collection could increase the external and internal recognition of the importance of the activity, inspire research institutions to improve their performance and encourage Portuguese companies to engage.

- Selection of more meaningful criteria and benchmarks for technology transfer performance evaluation (which includes measures of 'downstream' economic value) could help to improve targeting of government assistance

Threats:

- Difficult IP transactions between companies and TTOs may drive International and Portuguese companies to seek foreign alternatives.

- Research organizations will not receive maximum benefits of their IP if technology transfer arrangements are too loose. Universities typically do not take an equity interest in 'their' spin-off companies which limits their ability to participate in the exploitation of their IP and may reduce their interest and motivation.

- Portuguese companies (especially SMEs) that are not comfortable with IP are unlikely to recognize its potential value and will be unable or unwilling to negotiate appropriate (or fair) agreements with research institutions. This could inhibit the frequency of technology transfer and limit the market for IP in Portugal.

- Portuguese TTO staff may be de-motivated by lack of opportunities to train, network, and gain experience of success in technology transfer, this could make TTO staff recruitment, retention and improvement more difficult.

- Measurement of technology transfer is flawed in Portugal and in most other countries in its peer group. Infrequent, incomplete and inappropriate measurement may lead to a poor external image and demotivation for all the parties involved, especially TTO staff. The measurement criteria, the participation rates of TTOs and the understanding of the impact that TT has on companies, should all be improved.

- A systemic lack of investment in new technology development (e.g. proof of concept programmes) may prevent technology being transferred out of Portuguese institutions due the IP being regarded by companies (Portuguese and International) as immature and therefore too high risk to license and commercialize.

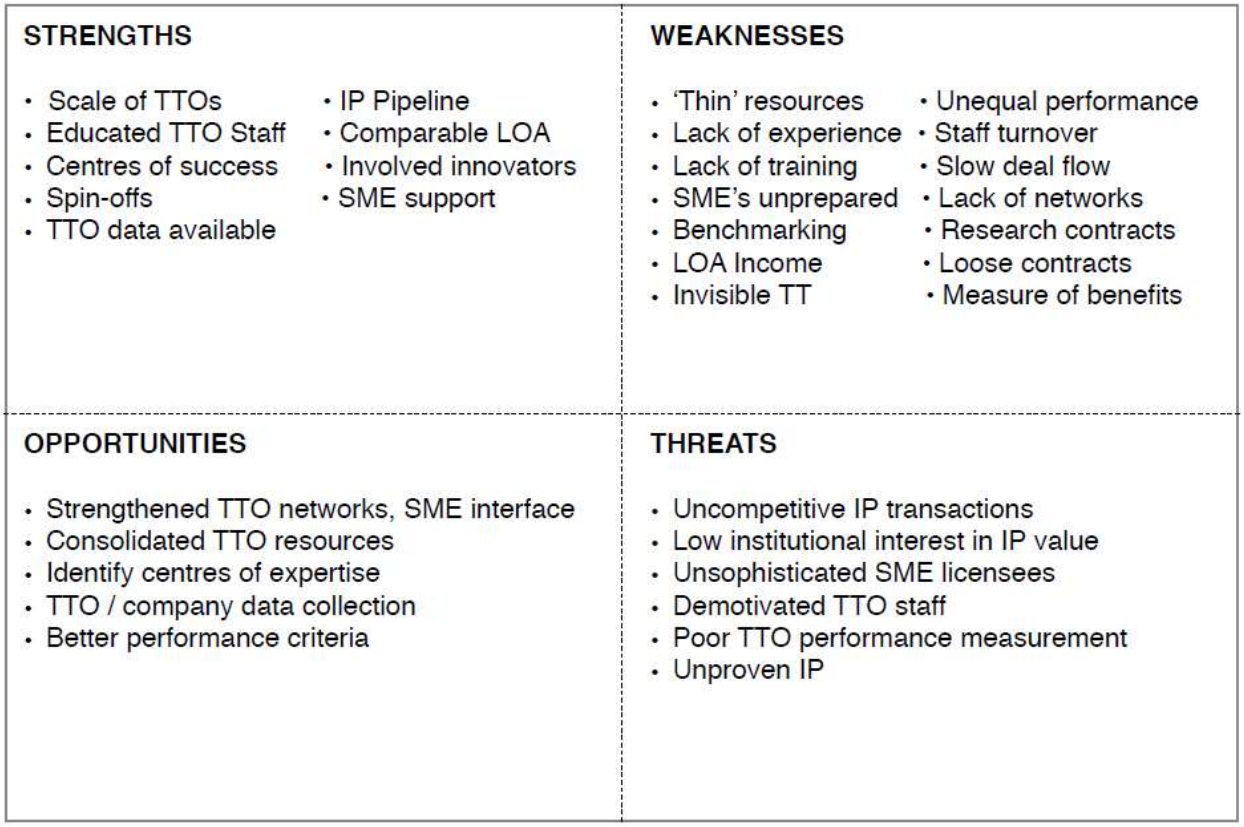


Figure 1. SWOT Analysis for the Portuguese TTO landscape

Table 10. International TTO Performance

Country	no of Institutes surveyed	TTO Foundation date (average)	Institutional Research Funding (€)	Research Contracts	Income from Research Contracts (€)	Invention Disclosures	Priority Applications	LOAs - 2016	Total Active LOAs	Income from LOAs (€)	Spinouts
Portugal	85	2006		914			251	266		1,015,000	389
Switzerland	11	2000		2,113		543	279	191	1,615	9,784,200	62
Ireland	24	2005	534,069,776	1,984	44,660,583	461	116	186	929	2,700,000	28
Denmark	14	2004		4,283			165	143	528	3,916,900	22
Czechia	18	2010			13,212,926		221	106		450,296	
Israel	19	1988			180,000,000	1,328	635	234		341,000,000	34
UK	162		41,711,000,000	34,336	1,245,560,000	4,358	2,066	43,631		140,000,000	33
Australia	111		7,227,280,000	16,139	1,127,438,600	1,503		890	3,215	80,520,000	46
Data Source											
Portugal	ANI Survey of Technology Transfer offices 2015-2016.										
Switzerland	'SwiTT Report 2017': https://switt.ch/system/files/standard/documents/swittreport2017.pdf										
Ireland	Annual Review & Annual Knowledge Transfer Survey 2016 published by KTI Knowledge Transfer Ireland. https://www.knowledgetransferireland.com/About_KTI/Reports-Publications/KTI-Review-and-Annual-Knowledge-Transfer-Survey-AKTS-2016.pdf										
Denmark	Styrelsen for Forskning og Innovation. https://ufm.dk/publikationer/2018/viden-til-vaekst-offentlig-privat-samspil-om-forskning-2018										
Czechia	Overview of Technology Transfer Offices and Other Members of Transfera.cz. Published by Transfera.cz, July 2017.										
Israel	Survey of Knowledge Commercialization Companies in Israel 2017 Reports on Inventions, Patents, License Agreements, Income and Startup Companies https://www.cbs.gov.il/en/mediarelease/pages/2018/survey-of-knowledge-commercialization-companies-in-israel-2017.aspx										
UK	HESA HEBCI Survey 2015_16 Table 4a										
Australia	National Survey of Research Commercialisation (NSRC) conducted annually by the Australian Department of Industry, Innovation and Science.										

APPENDIX A

Table 11. International TTO Performance. Normalized for GDP

Country	no of Institutes surveyed	TTO Foundation date (average)	Institutional Research Funding (€)	Research Contracts	Income from Research Contracts (€)	Invention Disclosures	Priority Applications	LOAs - 2016	Total Active LOAs	Income from LOAs (€)	Spinouts
Portugal	85	2006		914			251	266		1,015,000	389
Switzerland	11	2000		716		184	95	65	547	3,316,678	21
Ireland	24	2005	342,352,421	1,272	28,628,579	296	74	119	596	1,730,769	18
Denmark	14	2004		2,914			112	97	359	2,664,558	15
Czechia	18	2010			12,953,849		217	104		441,467	
Israel	19	1988			116,129,032	857	410	151		220,000,000	22
UK	162		3,511,026,936	2,890	104,845,118	367	174	3,673		11,784,512	3
Australia	111		1,212,630,872	2,708	189,167,550	252		149	539	13,510,067	8

Table 12. International TTO Performance. Normalized for Population

Country	no of Institutes surveyed	TTO Foundation date (average)	Institutional Research Funding (€)	Research Contracts	Income from Research Contracts (€)	Invention Disclosures	Priority Applications	LOAs - 2016	Total Active LOAs	Income from LOAs (€)	Spinouts
Portugal	85	2006		914			251	266		1,015,000	389
Switzerland	11	2000		2,641		679	349	239	2,019	12,230,250	78
Ireland	24	2005	1,068,139,552	3,968	89,321,166	922	232	372	1,858	5,400,000	56
Denmark	14	2004		7,138			275	238	880	6,528,167	37
Czechia	18	2010			11,776,226		197	94		401,333	
Israel	19	1988			200,000,000	1,476	706	260		378,888,889	38
UK	162		6,319,848,485	5,202	188,721,212	660	313	6,611		21,212,121	5
Australia	111		2,890,912,000	6,456	450,975,440	601		356	1,286	32,208,000	18

PART 3- Strategy for a National TTO Network

TABLE OF CONTENTS

TABLES

Chapter 1. Summary and Overview

This is the third and final report that documents work that 2Bio was commissioned to undertake by Agência Nacional de Inovação (ANI) in order to develop a study to define the best framework for creating a knowledge transfer network in Portugal. The Purpose of this report is to set out the major goals for the improvement of technology transfer (TT) in Portugal and to describe a strategy to achieve them.

The delivery of the strategy will be reliant on the ability to direct the necessary changes centrally, and therefore the initial stage of the strategy is to set up government-controlled infrastructure which will translate the strategic goals into plans in consultation with key stakeholders (The National Technology Transfer Board - NTTB) and create a team within ANI that will manage the transition process and maintain key enabling resources (National Technology Transfer Network - NTTN).

The strategy addresses issues that were identified in the second report of the work 'International Benchmarking of Portuguese TTOs', which included TTO comparisons from countries that are similar to Portugal, further analysis of a survey of TTOs that was completed by on behalf of ANI in 2017 and primary research on the issues affecting Portuguese TTOs and companies.

The key features of the strategy are the creation of larger 'Super TTOs' that consolidate TTO expertise, and other resources from multiple Research Stakeholders; and a managed TTO - Company interface that aims to optimize communication and understanding between these two parties. In addition, to these features the issue of improved mechanisms to measure technology transfer performance is addressed.

A series of highly specific strategic elements are also described, which represent more immediate opportunities to improve technology transfer that the (longer term) key features described above. The specific interventions are the creation of a Technology Transfer Toolkit, the launch of a National TTO Conference, and improvements to the design of the (annual) TTO Survey.

Consideration is given to the task of implementing these changes and specific strategies are included that are designed to improve the chances of success, including a pilot project to set up the first Super TTO as an exemplar.

The strategy represents a plan for significant change to the Portuguese technology transfer infrastructure and inter-relationships which, if implemented, should enable both short-term and long-term improvements.

Summary of Recommendations for Strategic Interventions	
1. Establish NTTB and NTTN	New enabling TT network resources and management
2. Create Super TTOs	S1: Strategic (complex), long-term intervention
3. Develop TTO-Company interface	S2: Strategic (complex), long-term intervention
4. Improve TT Measurement	S3: Strategic (complex), long-term intervention
5. Develop TT 'Toolkit'	D1: Discrete (specific), rapid intervention
6. Establish National TTO Conference	D2: Discrete (specific), rapid intervention
7. Implement Annual TTO Survey	D3: Discrete (specific), rapid intervention

Chapter 2. Overarching Strategy

The previous 2Bio Reports have identified areas for improvement of technology transfer infrastructure and processes in Portugal which are described in more detail in the following chapters of this report, and may collectively form the basis for a National Technology Transfer Strategy. The interventions that are proposed will require an overarching approach in order to co-ordinate their implementation on a national scale. Potential actions that could achieve the necessary organization of TT improvement are described here. ANI is the Agency that is most closely involved with technology transfer, and therefore it has been assumed that ANI would be responsible for implementation; however, it is possible that other agencies (existing or new) may be suitable to undertake this plan.

2.1. National Technology Transfer Board.

ANI commissioned a survey of all Portuguese technology transfer infrastructures (2017) and commissioned the current 2Bio work[85] which has identified issues that, if addressed, could improve technology transfer performance. The next step in this process would be to discuss the findings of these reports with relevant stakeholders and solicit comments and further opinions on the feasibility of implementing the proposed strategy, and build a consensus on the best way forward.

A National Technology (or Knowledge) Transfer Board (NTTB) should be created that can be responsible for drafting, reviewing and implementing the National Technology Transfer Strategy. The Board, including the chairperson, should be appointed by ANI, to include relevant expertise and to represent key stakeholder interests, the foremost being government economic interests, other interests should include academic research and industry.

2.2. National Technology Transfer Network

Once the NTTB has agreed the elements of the National Technology Transfer Strategy, the next stage should be to create the National Technology Transfer Network (NTTN), a grouping of core resources that will reside within ANI, which will be governed by the NTTB and which will administer the technology transfer infrastructure and supply the key centralized TT support services.

The NTTN will be led by its Network Manager, an ANI employee, who will re-assign or hire new staff to support the relevant infrastructure and services outlined in the later chapters of this report, including the Portal for Industry, the team of Industry Support Specialists, and the working groups for establishing new TT elements (such as toolkits and conferences). A major role for the NTTN will be to implement a process for creating a new network of Super TTOs, and to act as a

[85] 2Bio Report 1 'Analysis of the Activities of Portuguese TTOs 2015-2016' and 2Bio Report 2 'International Benchmarking of Portuguese TTOs'.

hub for this network once it is established. The NTTN will facilitate collaboration and co-operation between TTOs (such as sharing niche TT expertise) and will organize regular meetings with Super TTO directors and other key staff to review the progress of Super TTOs. The NTTN will be responsible for collecting and evaluating performance data.

Chapter 3. Strategic Goals and Interventions (S1, S2, S3)

The previous parts of this work (Part 1: 'Analysis of the Activities of Portuguese TTOs 2015-2016' and Part 2: 'International Benchmarking of Portuguese TTOs') were concerned with analyzing data from Portuguese TTOs, and benchmarking TTO performance within a 'peer group' of countries that are comparable in several respects to Portugal. Further analysis and additional feedback from Portuguese TTOs was used to draw out the important features of TTOs and make observations on the relative strengths and weaknesses and the consequential opportunities and threats that should be considered as the basis for a strategic plan to improve the performance of technology transfer in Portugal. A summary of these observations can be found in the SWOT analysis in Part 2, section 4.3.

The major goals of this work are to improve the performance of technology transfer activities in Portugal so that it benefits the national economy. In this section, these goals are defined in more detail and are considered in the light the SWOT analysis in order to identify strategies that may fit the current circumstances of the technology transfer sector and that can become elements in a pathway to achieving these goals. Three strategic interventions are proposed: S1; S2 and S3.

3.1. GOAL: Improve the current performance of TTOs (S1).

The analysis shows that there are aspects of TTOs in Portugal that are sub-optimal, and feedback from within these organizations has self-identified significant issues and weaknesses. In the current technology transfer system, the TTOs are at the heart of the process, forming a critical interface between research outputs and industrial innovation. Therefore, to improve the success rates of technology transfer it is vital to understand which processes require improvement and how the current infrastructure could be upgraded to support this.

Issues: The SWOT analysis identified the following weaknesses that are relevant to TTOs:

- 'Thin' resources- The human resources and budgets are distributed over a large number of offices and organizations, who work largely independently of each other.

- Uneven Performance- Successes in technology transfer are concentrated in a very small number of TTOs and many TTOs report no meaningful technology transfer outcomes.

- Human resources- TTO staff lack experience, training opportunities, and are difficult to retain.

- Autonomy- TTO programme funding is unpredictable and managers are insufficiently empowered to oversee research outputs and influence optimal commercialization pathways.

- Network- TTOs are disconnected from each other and from critical stakeholders (industry).

The overall size of the Portuguese TT infrastructure is relatively large with more than 800 FTE recorded in the 2015/2016 ANI survey, however it is distributed over a large number of TTOs (at least 85) which do not appear to share their human (or other) resources with each other. The budgets for some TTOs are very small, which may reflect low institutional priorities, and any larger budgets are likely to be associated with specific and occasional funding programmes which may place varying external pressures on priorities that could be in conflict with technology transfer functions. Some TTOs report being marginalized and dis-empowered in their relationships with their 'parent' organizations, which can result in circumvention of good TT practice by researchers, loss of commercial opportunities, or simply an inability to record activity ('invisible TT'). The relatively high numbers of well-educated TT staff lack training opportunities, career structure and peer networks and are generally inexperienced, demotivated and prone to leaving the sector to seek other employment [86].

3.2. Potential Solutions to improve TTO performance (S1).

In general, there appears to be an opportunity to re-organize the TTO infrastructure to position it for improved performance and to better meet the current and future demands from the economy, by considering the following changes (which are aligned with the issues identified):

1. **Grow the size of technology transfer teams.**

The examples of top-performing TTOs in Part 2, indicate that they had built TTO teams of up to 25 staff, which could call on additional specialists for support. This is greater than the average size of Portuguese TTOs (10 FTE) and much greater than the average size of Academic TTOs in Portugal (5 FTE). Therefore, an increase in TTO staff numbers would be consistent with the practice observed in well-regarded TTOs. The rationale for larger team sizes is that it would

[86] Conclusions based on multiple interviews conducted by 2Bio with Portuguese TTOs as reported in Part 2 of this work.

increase mutual support for TTO staff, increase the range of experience and skills available, and increase opportunities to transfer skills and learning between team members (internal training).

2. Improve consistency of funding for budgets

The funding for TTO budgets in Portugal is varied, depending on the role that the TTO plays - those that are closely associated with higher education institutions are dependent on their institutional 'parents' for their funding, while other TTOs access a variety of public funding sources. It is clear that TTOs adapt their operations depending on the funding programmes that are available to them at any one time, and therefore the focus of their activities changes periodically to reflect this, potentially resulting in staff losses or re-deployment to meet new programme priorities. A good example of this is the funding emphasis on teaching entrepreneurial skills to innovators, which is an important element of the innovation ecosystem, but may be distracting from the 'core' activities that support technology transfer and 'deal flow'. A more consistent funding strategy, whereby long-term funding is available to support core TTO functions would allow TTOs to be more confident in staff recruitment, training and career development, eventually improving staff quality. The example of VIB has relevance to this issue: the Flemish government provides consistently strong funding to VIB, including its TTO, which is reviewed every 5 years, and is adjusted according to the objectives being met [87].

3. Reduce the number of independent TTOs

Portugal has a much larger complement of TTOs than its peer group of comparable countries. The ANI Survey in 2017 identified 136 offices, which were believed to have some technology transfer activity and confirmed 85 offices that had substantial technology transfer operations. This compares with the average of 17 TTOs in the other countries of the cohort of close comparators (Switzerland, Ireland, Denmark, Czechia, Israel). Since the technology transfer activity is not greater that that of the other countries, this high number of independent TTOs represents an excessive amount of duplication of technology transfer capacity in Portugal. The number of independent TTOs could be reduced by combining current offices, which would then provide services to multiple institutions or stakeholders. This approach would also be consistent with the objectives of increasing the size of technology transfer teams (as described above). As part of this strategy, some existing TTO staff could be designated as technology scouts (part of the Technology

[87] See Part 2 of this work 'International Benchmarking of Portuguese TTOs Section 2.1.3, p29.

Scoping Teams) and be retained by each employing research institution, where they would be dedicated to those research portfolios. The concept of TTOs servicing multiple stakeholders occurs in Sweden, Denmark and the UK, and in Denmark in particular has enabled the extension of the technology transfer infrastructure into the national network of research hospitals [88]. As part of this re-organization the separation of entrepreneurship training programmes into separate 'academies' may allow the TTOs to focus resources into technology transfer.

4. Increase the range of services and expertise available from TTOs

Currently most TTOs do not offer the full range of services and support that may be available in the best examples of high-performing offices. This limitation affects the ability of TTOs to provide rapid and appropriate support for their IP assets, and may result in some assets being lost. It is notable that the most successful TTOs in Portugal (in terms of LOAs) can offer support for evaluation and protection of IP, while others do not. TTOs should be re-structured to ensure that their core team possess the skills and experience needed to offer a full range of technology transfer services, from evaluation of technical and commercial feasibility, through IP development programmes (POC), IP protection and negotiation of 'transfer' agreements. In addition, the ability of teams to support commercial research contracts (through commercial and IP advice) would be helpful. Additional functionality could be added by including expertise, such as commercial or IP attorneys and accountancy, but this could also be outsourced if budgets do not permit. Support should also be offered for 'entrepreneurial' projects, such as business planning. In this way the re-structured TTOs would be at the heart of a highly functional technology transfer ecosystem and possess the capabilities to convert a much higher proportion of portfolio projects into success.

5. Increase TTO autonomy

The vast majority of European TTOs are divisions or offices of a higher education or research institution, where the 'parent' institution controls the goals, operational strategy, human resources budget, and often the major operational decisions around technology transfer 'deal flow'. This situation can lead to conflicts of interest or disempowerment of TTO management and staff which can affect progress and motivation. Feedback from Portuguese TTOs in this work suggests that they perceive institutional control as restrictive, and that their influence over their destiny is sub-optimal due to lack of senior-level representation by TTOs within their institutions'

[88] See Part 2 of this work 'International Benchmarking of Portuguese TTOs Section 1.4, p14.

executive (i.e. a lack of 'champions'). In order to address this situation TTO's should be given more autonomy to make operational and strategic decisions with respect to TT activities. One way to achieve this would be to re-configure the relationship between TTOs and their 'parent' institutions so that the TTO has more independence and is at 'arms length' and is seen as a service provider rather than an integrated department. Examples where the 'arm's length' approach has been successful include the TTO ecosystem of the Karolinska institute and all of the Israeli TTOs.

6. Increase co-operation between R&D stakeholders

The majority of TTO 'parent' institutions in Portugal act independently of each other with respect to TT activity, they do not obviously co-operate with their peer group of institutions to any great extent. This behavior may result in the loss of opportunities to form partnerships, to assist in technology transfer, or to benefit from shared experiences. There are examples of TTOs taking a much more collegiate approach when there is no designated 'parent' institution, this is more common for science parks and some technology incubators; however, these 'TTOs' do not have any significant technology transfer activity (as they are working on other people's IP assets). The I3S organization in Porto is a rare example of co-operation between major research institutions (with a focus on biomedical science) where the technology transfer staff of each of the three founding institutes work as an enlarged team, and it is notable that this TTO has reported the best LOA income in Portugal. Opportunities to increase co-operation between R&D stakeholders should be explored, especially where they have complementary or synergistic research activities, including the scope for sharing technology transfer infrastructure. Co-operation of this type could be beneficial for many direct reasons and extending the scope of co-operation to stakeholders that are not typical technology transfer targets (such as Portugal's hospitals) may add significant functionality to the TTOs' ecosystem and increase the value of its IP assets. The recent CoLAB programme is expected to generate commercially valuable IP; however, it is not clear if or how existing TTOs will interact with this programme, and there may be opportunities to configure collaborations here [89].

3.3. Intervention S1. A new 'Super TTO' Model.

A new 'Super TTO' model is proposed that will address the need to improve TTO performance in Portugal - the model's main feature is the concentration of high-quality TT resources into one or more centralized offices, which service the needs of a broad range of stakeholders and within which multiple associated assets are available.

[89] The FCT CoLAB Programme funds research and innovation partnerships between companies and R&D units from higher education institutions. See https://www.fct.pt/apoios/CoLAB/index.phtml.en

3.3.1. Super TTO: Governance & Evaluation (S1).

The Super TTO Model is based on an enabling level of autonomy for a core Team (underpinned by financial and political stability), and a high degree of co-operation with stakeholders and relevant resources.

The governance structure for a Super TTO will have a board (the Board) at the top, to which the director of the Super TTO will report. The Board will be constituted with senior representatives from the Research Stakeholders that provide funding, and will be led by a Chairperson who will be appointed by ANI on behalf of the Government of Portugal, which is expected to provide the largest share of the budget. The Chair should not have any interest in, or allegiance to, any of the Research Stakeholders, to ensure that there is no undue influence over the work of the Board. Other Board members may be appointed according to their interests in, or contributions to, the Super TTO. The Board may appoint advisors to the Super TTO who may provide expertise in related matters (strategic, financial, legal, commercial) and who may participate in regular reviews.

The Director should not be an employee of any of the Research Stakeholders and will not report directly to any one of them; in this regard the Director will be autonomous. The Director will have authority in all operational matters including human resources, finance and commercial agreements. The Director will be responsible for appointing and managing the Super TTO Team, and for coordinating the participation of the Research Stakeholders and the associated TT assets.

The Director may delegate authority to members of the Super TTO Team to take decisions related to IP arrangements, commercial transactions or other similar activities. With respect to IP, the Super TTO will not assume the ownership of the IP portfolio or the research assets which it services, which will remain the responsibility of the relevant Research Stakeholders [90]; however, as a condition of participation, the Research Stakeholders will delegate their authority to the Director for decisions relating to management of the IP rights connected with any of the Super TTO's active Projects.

The Research Stakeholders will be expected to reduce their current TTOs, maintaining only a smaller Technology Scoping Team. The excess staff from these TTOs may be suitable for employment by the Super TTO.

3.3.2. Super TTO: Financing (S1).

[90] In Scotland, the Intermediate Technology Initiative (ITI), 2005-2010 was a £450 million government programme to own and develop the IP from Scottish Universities. The programme was terminated early due to failure to achieve any significant commercialisation, despite assuming significant IP portfolio costs. See https://research-repository.st-andrews.ac.uk/bitstream/handle/10023/9084/BrownAcceptedVersion5_11_14.pdf?sequence=1&isAllowed=y

The income to support the operations of Super TTOs will come from mixed sources: primarily from national and regional governments; however, a significant element will be an appropriation at least equivalent to the Research Stakeholders' current budgets for technology transfer activities. The precise funding models will be determined by the competition to establish each new Super TTO (which will include commitments from all the participating stakeholders). The Board will agree the annual operating budgets, based on the initial accepted proposal for establishment, and will review the core operating plan every 5 year.

An outline of budget cost items for setting up and operating a new Super TTO (based on certain assumptions) is shown below in Table 1, Below.

3.3.3. Super TTO: Operation and Management (S1).

The elements of the proposed Super TTO model are described below and a diagrammatic representation of the model is shown in Figure 1 (pág. 131).

Super TTO Office

The Super TTO central office will comprise multiple staff positions (Team), that have the skills and experience to service the variety of different project types and specific tasks that will be presented from its research stakeholders. The Team will be led by a Director, who should be experienced in TTO management. The director will be supported by an office administrator. The Team should also include the following staff positions:

Project Manager(s)- These positions will be responsible for creating and progressing TT projects, primarily based on information supplied by the Research Stakeholders. Project Managers will manage the flow of communications between stakeholders and the Super TTO and will perform the key role in delivering the core activity of the office. Project Managers must have both technical and business competence and will take primary responsibility for their projects, working closely with other specialists within the Team and coordinating access to associated resources, where appropriate.

Grants Specialist- This position will gather intelligence on appropriate sources of grant funding or other sources of finance that can support the Projects, and will also support the grant application process (directly, or in association with Research Stakeholders). The Grants Specialist will liaise with relevant funding agencies directly, and maintain good communications channels.

Market Researcher- This position will investigate the commercial feasibility of the Projects through primary and secondary research and will produce evaluations that will inform the pathways for commercialization. Market Researchers may also be available to provide business planning services for spin-off companies.

Patents Specialist- This position will investigate the feasibility of protecting the IP that is associated with a Project, and will assist in developing and maintaining formal IP protection (in association with legal professionals). The most senior Patents Specialist will be responsible for day-to-day management of the IP portfolio (on behalf of the IP owners, by agreement).

Licensing Executive- This position will create licensing strategies for Projects, develop relationships with potential licensees, and ultimately negotiate and execute license agreements, working closely with the Contracts Specialist.

Contracts Specialist- This position will require some legal training for contracts (paralegal) and will be responsible for drafting contracts and agreements to support IP licensing and other aspects of technology transfer, including confidentiality agreements, materials transfer agreements and any relevant aspect of agreements made by stakeholders with respect to Projects (e.g. research contracts).

Industry Liaison Specialist- This position will require experience of working within relevant industries. The specialist will maintain industry awareness and develop trusted relationships through networking with companies. The Industry Liaison Specialist will receive and discuss enquiries from industry related to their technology requirements (directly, via 'portals' or via the NTTN's ISS) and will attempt to source solutions from within the Team or directly from the Technology Scoping Teams from Research Stakeholders.

The positions described above are a recommended level of skills for a TTO that is servicing the R&D pipelines of its Research Stakeholders; however, the number of staff required will be scaled according to the size and diversity of the operation - i.e. servicing of more and diverse Research Stakeholders would require proportionally more staff (as the volume and types of Projects increases). Further specialization of staff may be justified for larger scaled operations, for example it may be more cost effective to hire 'in house' lawyers and accountants for very large Super TTOs.

Research Stakeholders

The model requires participation from multiple Research Stakeholders in order to increase the scale of research outputs that can be commercialized, and to ensure that any individual Research Stakeholders do not dominate the priorities or governance of the Super TTO. The larger the number of stakeholders and the more diverse, the better. It is recommended that there are multiple universities, research institutes and hospitals as Research Stakeholders.

Each Research Stakeholder will be expected to maintain its own Technology Scoping Team. These teams will be responsible for: maintaining awareness of the Stakeholder's own research activities; maintaining relationships with research groups; mentoring innovators (on IP and commercialization); frequent communications with the Super TTO; and, suggesting new Projects. In addition, the Technology Scoping Teams may procure other agreed services from the Super TTOs, such as assistance with grant writing, or IP advice.

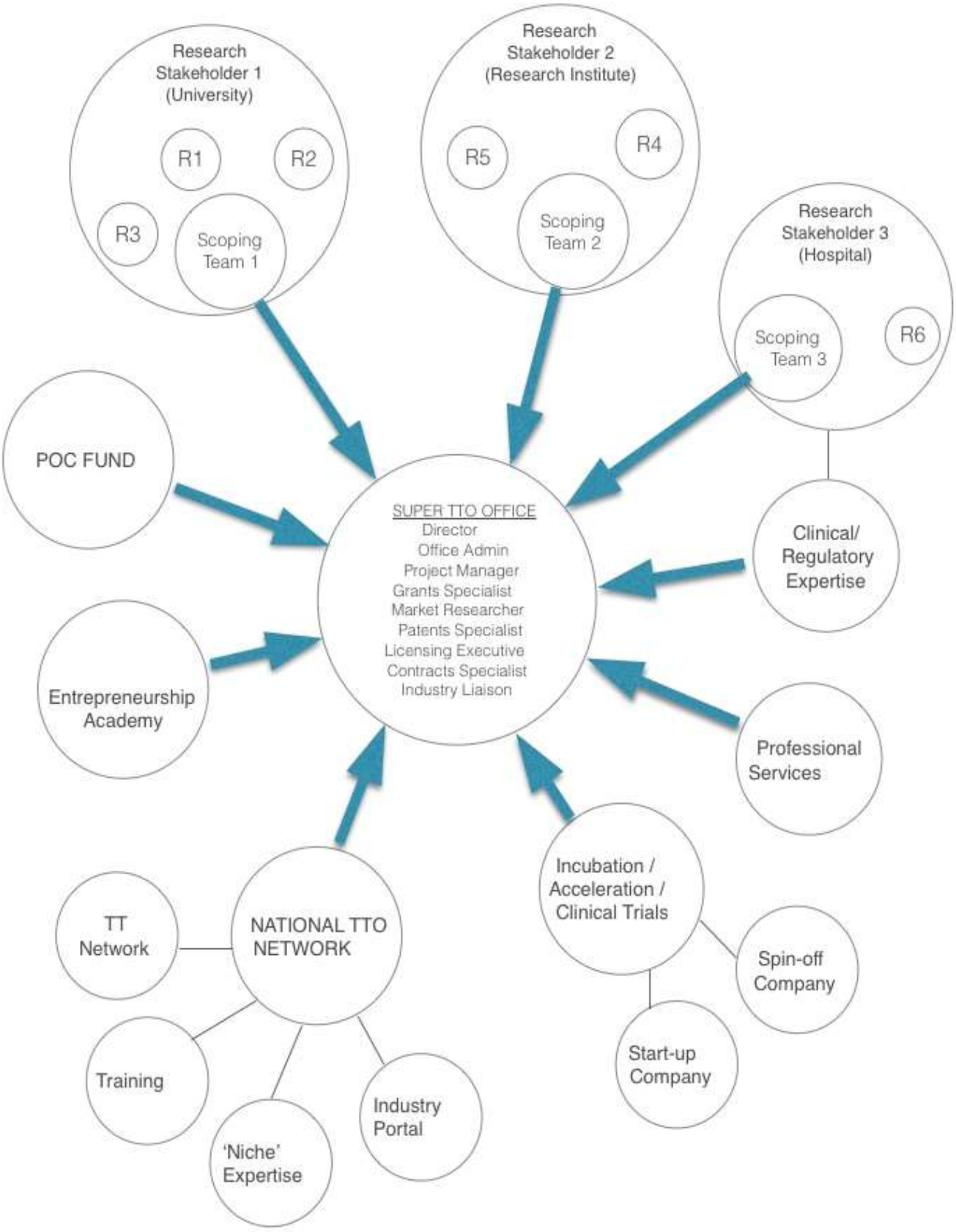


Figure 1. Diagram showing the main features of a 'Super TTO'

The Technology Scoping Teams should be appropriate for the size and diversity of its research portfolio. It is anticipated that the Technology Scoping Teams would be recruited from the personnel that are currently employed by TTOs. Where a Stakeholder is a new organization, or is new to research (e.g. hospitals), then the Super TTO should assist with appointing and training a Technology Scoping Team on behalf of the Stakeholder, with the expectation that the team will eventually be transferred to the Stakeholder.

Research Stakeholders will be expected to provide funding for their own activities; primarily the Technology Scoping Teams, but also the costs of filing and maintaining its IP portfolios (delivery of which will be delegated to the Super TTO).

POC Fund

The Research Stakeholders will be encouraged to establish proof-of-concept funds, which will be used to develop and add value to their IP, as part of the commercialization pathways undertaken by the Super TTO. Co-operation between Research Stakeholders for POC funding may offer benefits, such as reduced administrative overheads and increased opportunities for collaborative projects.

Entrepreneurship Academy

The formation of Super TTOs may provide an opportunity for the Research Stakeholders (and other stakeholders) to establish an independent 'Entrepreneurship Academy' which would form part of the technology transfer ecosystem surrounding the Super TTO. An Entrepreneurship Academy would assume all the current entrepreneurship activities of the stakeholders and consolidate them into a single organization. Such an Entrepreneurship Academy would be an important resource for any Projects that are more appropriate for spin-off (than licensing) and the Super TTO may provide services to it, such as IP, legal or contracts support. An Entrepreneurship Academy would be expected to have the ability to create business plans, which may be a useful service to offer the Super TTO. Entrepreneurs that have received support from the Entrepreneurship Academy, and who have created plans to commercialize IP, may then seek support from the Super TTO to fulfil those plans, where appropriate, and may also seek support from the associated Incubators.

Incubators

Incubators, accelerators and related facilities such as clinical trials units would be important assets within a Super TTO ecosystem. These facilities, and their networks, can provide options for developing Research Stakeholder's IP through start-up companies. Once established, these companies may raise investment that can fund the cost of 'Proof of Concept' programmes or similar technology developments such as clinical trials. At this point, the companies may seek to

license the IP, and in this case the Super TTO could offer its services to assist - assuming that a Research Stakeholder has a retained interest in the IP or in the company.

Clinical Expertise

Technology transfer Projects that are targeted toward medical and healthcare markets can benefit from early input from clinical experts, who can advise on market conditions, development pathways and regulatory issues. When these issues are addressed, the feasibility of the IP is strengthened. Therefore, the availability of clinical advisors would be a valuable element in the ecosystem. If the Research Stakeholders include a research hospital, then the Super TTO should make arrangements for access to suitable expertise; and if not, then expertise should be sourced directly from appropriate providers (for instance by setting up an independent clinical advisory panel) or by accessing existing clinical advisory panels through networks.

N.B. If the research portfolios of a Super TTO are aligned towards other specific markets (such as agriculture or energy) then similar advisory panels should be set up to provide market specific guidance during the development of Projects.

Professional Services

The Super TTO will require professional support for activities such as IP applications and prosecutions, commercial contracts, financial analyses, marketing and publicity. If the Super TTO is configured to be sufficiently large, these services may be provided 'in house'; however, specialized professional services such as patent attorneys are always likely to be outsourced. The Super TTO may negotiate beneficial commercial terms with a range of professional service providers (based on volume of business), such terms may also be made available to other organizations in the ecosystem.

National TTO Network

The new Super TTOs will require national funding and would benefit from national-level oversight and co-ordination. Therefore, it will be appropriate for ANI to create a National TTO Network (NTTN) that will support and guide the Super TTOs, connecting them with each other and with industry and coordinating networking and training opportunities (which are described in more detail in Chapter 4). Another valuable opportunity that could be provided by such a network is the registration of TT skills that can then be made available to Super TTOs that cannot access them from their own teams or stakeholders.

3.4. GOAL: Improve the Interface Between TTOs and Industry (S2).

The analysis and feedback presented in this work (Parts 1 and 2) shows that there is scope to improve the interface between Portuguese TTOs and industry. Industry is the destination for technology transfer and therefore any issues that prevent technology from flowing from the R&D base into industry should be addressed as a high priority.

Issues: The SWOT analysis identified the following weaknesses that are relevant to Industry:

- Lack of networks- Industry is disconnected from TTOs and the R&D base.

- Deal flow- Companies and TTOs suffer from protracted negotiations, due to cultural differences and lack of empathy.

- Lack of IP experience- Company staff are not sufficiently familiar with IP, which inhibits appropriate valuation and agreements (especially in smaller companies).

Technology flow requires good connectivity between the developers of new technology (within research organizations) and technology users (commercial companies). Technology transfer offices provide an interface to manage this flow and can encourage the push of their technologies into the industrial sector and understand the pull for new technology from companies seeking to innovate. The success of this interface relies on good relations and good communication channels between TTOs and industry. However, it is clear that TTOs and companies both perceive a lack of good communication channels and regular networking opportunities. The result of this situation is that TTOs struggle to make companies aware of the technologies that their stakeholders have developed, and the capabilities that they can offer, and companies have no obvious means to search for technical support from research organizations to address their specific problems or issues. When TTOs and companies are able to connect and attempt to reach agreement, there is evidence that this is a very difficult process, where negotiators do not always recognize the position of the other party, do not appreciate the nuances and legal nature of IP, and are frequently unable to prioritize the completion of agreements.

3.5. Potential Solutions to improve the TTO - company interface (S2).

Specific solutions that could be considered to address these issues are described below. However, it should be noted that some issues with the interface between TTOs and Industry may be addressed by the improvements to the performance of TTOs proposed in Sections 3.2 and 3.3, above; for instance, the inclusion of industry liaison specialists in Super TTOs Teams will improve dialog between TTOs and companies.

1. Provide companies with access to a register of useful skills and technologies.

The feedback from TTOs and companies that was considered in Part 2 of this work indicates that companies find it very difficult to understand what technologies and skills are available within the Portuguese R&D base, that can meet their specific technology-related needs. For their part, TTOs also find it difficult to advertise their IP and capabilities to appropriate people within companies. A potential solution to this problem is to create a register of useful technical skills, resource capabilities and IP, gathered from the Portuguese research base, and make this available to companies. The data should be provided by TTOs, who would ensure this is kept up-to-date. And the TTOs would provide contact details of a member of staff to handle any inquiries that are generated.

2. Develop a human resource to liaise with TTOs on behalf of companies.

Companies require a channel to interrogate the research base in an intelligent manner, that can lead to customized technology solutions that meet their needs precisely. This capability would be managed by one or more 'Industry Support Specialists' (ISS) who would act on enquiries from companies and then work with the TTOs to develop the options that can be considered by the company. Although this capability is closely related to the skills/technologies register described above, the role of the procurement specialist will be to understand the company's issues and then procure a solution from all the resources that are available via the register, the TTOs and their Research Stakeholders. The Industry Support Specialist(s) must have a good grasp of technology and have experience and understanding of technology-driven companies; the ISS should also be able to work well with TTOs and researchers to scope out specific solutions where none may currently exist.

3. Develop a code of conduct to guide TTO interactions with companies.

When companies work with TTOs they can experience a much slower pace of progress with discussions, negotiations and completion of agreements, than they would expect when doing business with other companies. This leads to frustration and may prevent some relationships from becoming fully developed. Some of the causes of this situation may be a lack of empathy between both sides, a lack of 'ownership' of the project within the TTO, lack of available staff or delays due to the need for formalities (such as confidentiality agreements or materials transfer agreements). A measure that may impact positively on this situation would be development of a 'code of conduct' for TTOs that will guide the way in which Team members should deal with companies, and at the heart of this code would be an 'account management' approach to relationships with companies, as practiced in business for major client or customer management. This approach would require TTOs to enforce a single and consistent point of contact for each company relationship, and the TTO staff member would take responsibility for ensuring progress and minimizing unnecessary delays or obstacles. The 'account managers' (who could be any member of the Team) would preferably have experience of working for a private company and would therefore have empathy with their 'client's' viewpoint. This is essentially a process of 'cultural alignment' with companies.

4. Educate companies on the nature and characteristics of IP-related business.

Companies' unfamiliarity with IP is an issue that both TTOs and companies have recognized and is particularly acute in smaller companies. This unfamiliarity can be a source of disagreement and delays and therefore a significant impediment to technology transfer. Such companies may not understand the need to deal with IP according to established practices, and the need to include IP management in agreements such as research contracts. They may also object to assertions of IP rights that endure beyond a contracted piece of work. The formalities that must be observed when managing IP can also slow down the rate of progress in relationships with companies, and this may cause frustrations if the companies are unfamiliar with IP. To address this issue, TTOs can create IP guides for companies that wish to access or develop IP, to familiarize them with the principles, prepare them for the procedures that must be followed and the conventions that are usually observed. In this way companies could become 'culturally aligned' with TTOs.

5. Establish regular structured networking events to bring TTOs and Industry together.

The most frequent issue raised by both companies and TTOs when considering the issues that may impede the technology transfer interface was the lack of regular, structured networking opportunities and poor communication channels (see Part 2). The most obvious solution to these issues is to organize regular events which will attract TTO staff and technology-driven companies and at which there are both informal and managed networking activities. The key to success of this event will be the attraction of a critical mass of participants from both sides, and therefore it must be seen to have value and to stand out from any other potential distractions. The structure of the event will be important, it should provide a platform for companies to outline their technology needs, and TTOs to list new technology developments and available IP. At the heart of the event would be managed partnering for 1-to-1 meetings, and good opportunities for informal networking. Ideally it should also provide opportunities to showcase good examples of TTO-industry deals.

3.6. Intervention S2. A Model for the TTO-Company Interface in Portugal.

A new model is proposed that will introduce new tools and processes to address the need to improve the TTO - company interface in Portugal - the outline model shows the ways in which companies may connect with TTOs and technologies, and new tools or features that may enhance these interactions; however, this is intended to assist the status quo, rather than to replace it, and it is appreciated that companies and researchers will continue to connect with each other outside of these mechanisms (shown in the dotted lines in the diagram below).

3.6.1. TTO-Company Interface: Governance and Evaluation (S2).

The TTO-company interface described in this model would be most feasibly managed as a service to be supported by the NTTN within ANI, since the centralized Portal for Industry and the Industry Support Specialists would be ANI resources and ANI employees.

The performance of this model will be evaluated periodically by ANI based on its own data and any additional relevant data generated directly by companies and stakeholders. Evaluations and any related performance issues will be discussed by the NTTB who will make recommendations for changes or improvements.

3.6.2. TTO-Company Interface: Financing (S2).

The core financing for maintaining the resources in the interface are expected to be provided by ANI (from a new budget allocation); however it would be important to seek financial contributions from industry to reinforce the shared responsibility of the interface, and to encourage active participation. The resources required for this model (in addition to the Super TTO Model described above) are:

1. The establishment and maintenance of the Portal for Industry, which would require a database, website and FTE for maintenance; however, it is likely that this resource can be shared with other relevant programmes within ANI.

3. The establishment of a team of Industry Support Specialists (ISS), to cover diverse industry sectors and technology fields. Initially, the FTE may be lower as activity builds (1-2), but this will ultimately rise to 3x FTE when fully implemented. The FTE may be increased proportionately above this level according to demand. The ISS are expected to cover diverse geographic areas within Portugal and are likely to incur additional travel expenses.

6.3. TTO-Company Interface: Operation and Management (S2).

The Diagram shown below (Figure 2) is intended to show the relationships and the communication channels between the various actors and resources.

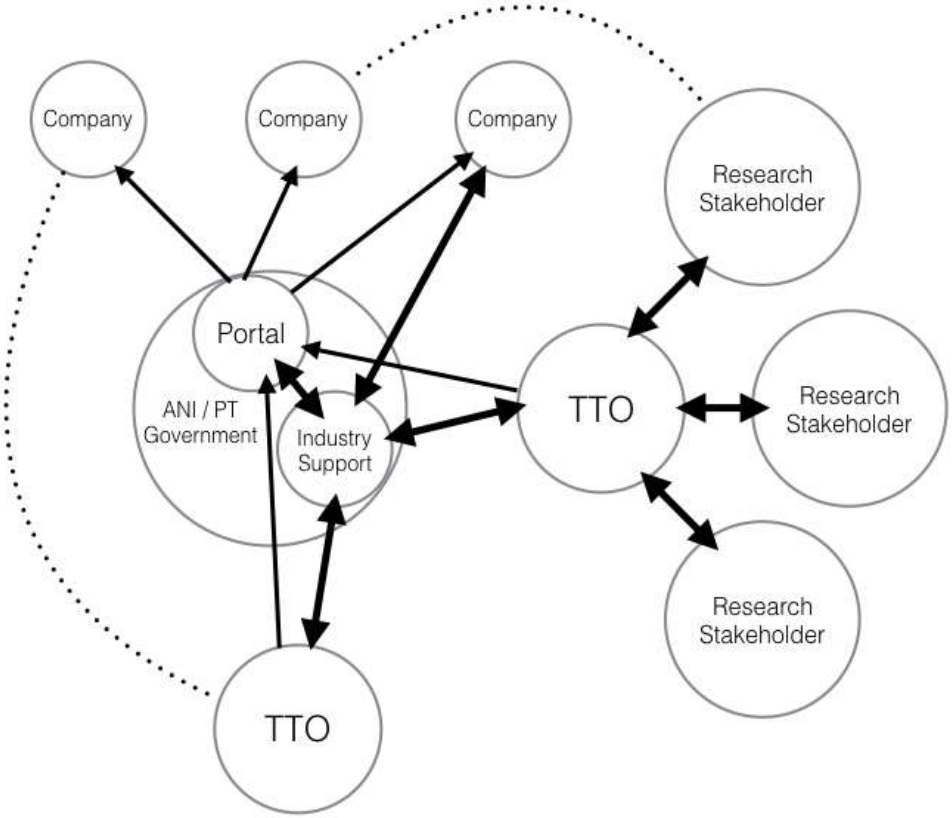


Figure 2. A diagram to show the elements and relationships in a new TTO-Company model.

In this model a register of technology assets is maintained by ANI (or another appropriate agency) and is made available to companies through a Portal for Industry that it maintains. The information in the register is supplied by TTOs who, in turn, gather the information from their Research Stakeholders.

Companies that find a technology asset of interest can seek further information via the Portal, and will be assisted by an Industry Support Specialist (ISS) within ANI (described below), who will work with the company to understand its precise needs. The ISS will then develop a procurement proposal and communicate this to all relevant TTOs to seek feedback, and will then work with key contacts at the TTOs to establish the optimum range of options that are available from their Research Stakeholders to meet the company's needs.

The ISS will discuss the options for potential technology solutions with the company and then, if any options are appropriate, the specialist will introduce the company to the key contact within the TTO, and periodically monitor progress of the relationship, providing further assistance as required.

ANI Resources

The critical elements in this model are the Portal for Industry and the Industry Support Specialist(s), both of which are proposed to be made available by ANI (or an appropriate agency of the Government).

The Portal will provide access to a current and useful register of technology assets in Portugal. The value of the register will be dependent on:

- Participation rates - it should aim to be a comprehensive list of IP, expertise, facilities, processes and research services that are available from all the Research Stakeholders in Portugal.

- Information updating - the information must be current and valid, therefore TTOs should supply and edit accurate information from their Research Stakeholders that is updated frequently, especially when any changes occur.

The Industry Support Specialists will be multi-skilled, their primary function will be to liaise with companies and respond knowledgeably to their enquiries, they will be expected to have a sound understanding of technology and, more importantly, empathy with industry - preferably having experience of working in this sector. The specialists will also maintain good relationships with key positions within TTOs, a third function will be to oversee the supply of data into the register of technology assets and periodically validate it. The number of Industry Support Specialists that will be required will be dependent on the volume of enquiries from industry that are generated through this activity; however, specialized sector knowledge will be an advantage,

and this may drive the need for multiple specialists to cover the necessary range of industry sectors.

An additional role for both the Portal and the Industry Support Specialists would be to support the set up and management of industry-TTO networking events.

TTOs

The TTOs will provide the other resources needed to operate this model. Each TTO should designate a staff member that will be responsible for liaison with the ANI Industry Support Specialist. Ideally the designated staff will be the TTO's Industry Liaison Specialist (as described in the model in Section 3.3, above).

The role of Industry Liaison Specialist in this model will be to take responsibility for scoping out solutions in response to enquiries from companies, working with the Industry Support Specialists and applying their knowledge of the research capabilities of their Research Stakeholders. If Companies respond positively, the Industry Liaison Manager would then take responsibility for managing that relationship, and ensuring that the project has structure, and purpose and that this is communicated to all parties involved.

Ideally the Industry Liaison Specialist will also take responsibility for their TTO's data submissions to the Register of Research Assets, as this will provide the advantage of familiarity with the full portfolio of assets on offer.

3.7. GOAL: Develop Meaningful TT Measurement Criteria (S3).

The research conducted for Part 2 of the work [91] served to highlight the imperfections that exist in the international systems for evaluating the performance of technology transfer. The most comprehensive examples of data gathering were observed in the UK which includes a wide range of data classes and sub-classes related to technology transfer. However, none of the agencies in the countries that were studied, gathered and published any meaningful data with respect to the consequential (or 'downstream') validation of technology transfer.

Knowledge of both the volume of technology transfer activity and the impact of that activity is vitally important for the correct planning and resourcing of technology transfer services. These metrics would allow strategists to understand where activity is located (i.e. who is performing technology transfer), who benefits from the activity and its quantitative impact.

The current international measures that most closely reflect transfer of technology are the number of research contracts (and the income generated from those) and the number of Licence, Option or Assignment (LOA) agreements (and the associated income). While this data can allow some understanding of the frequency with which higher education or research institutions engage with companies, and the contractual nature of the relationships, they tell us very little about the value that is created beyond the contemporaneous generation of revenues (which are usually the result of the new agreements that are reported in that year).

The ANI-commissioned survey of all Portuguese technology transfer infrastructures in 2017 considered a wide range of information types that have been very useful in understanding the composition, budgets, sector specializations and IP portfolios of TTOs, and also provided data relating to Research contracts, LOAs and Spin-off companies. However, there is limited data in some key areas such as longitudinal value of research contracts, LOAs and company spin-offs. This may be due to the inability of TTOs to request or collect this data from their industry partners.

In order to understand the economic impact that technology transfer is having on the Portuguese economy, new measurement criteria should be established that are accepted by all interested stakeholders as good performance indicators. These criteria should, for example, be able to track all the different benefits that are generated and should also follow each technology transfer through its life cycle to understand the full economic value that is being realized in real time.

[91] 2Bio Report Part 2: 'International Benchmarking of Portuguese TTOs'.

3.8. Potential Solutions to Improve Measurement of TT.

The following solutions could be considered to improve the effectiveness of technology transfer measurement in Portugal:

1. Identify and agree meaningful data that could be collected

In addition to LOA data, there are several other types of data that could show the economic value of technology transfer to the Portuguese economy. Useful data from companies may include the profits generated from the associated IP, jobs created (or secured) by the specific business enabled by the IP, or the proportion of the taxes paid by the company (local and national). Data from Research Stakeholders may include contract research income, funding provided for new equipment or facilities, or the number of employees working on projects related to technology transfer projects (where the cost is borne by the commercial partner).

The Government of Portugal has a vested interest in gathering the most meaningful information in this respect, and should consider convening senior level discussions, or workshops, with Research Stakeholders and relevant companies to set out the type of information it would like to gather. These discussions should seek the opinion of the representatives on the likely availability of such information and the willingness of the various stakeholders to share it. In this way, realistic goals may be established for data collection.

2. Make practical assessments of the feasibility of gathering data.

Commercial research contracts can lead to new employment, equipment purchases, commissioning of new facilities and other outcomes. It is likely that Research institutions already gather this data, and apportion costs to projects codes, so that costs can be passed on to the company. Access to this data would provide meaningful values of the immediate benefits to Research Stakeholders.

Companies that engage in technology transfer record a variety of forms of financial data; although summary data may be published by government agencies or the companies themselves (e.g. annual accounts), the detailed analysis that attributes revenue to specific projects or elements of IP, is seldom revealed. Mechanisms should be explored for obtaining and reviewing this information, including standard clauses in IP licencing agreements, or recording it on corporation tax returns.

Examples of useful data sources may include the 'intangible assets' category on a company balance sheet, which in start-up or spin-off companies is usually the value attributed to the value of their IP (patents). Companies may apply for R&D tax credits, which require significant documentation on Project spending, this information would therefore be potentially available to verify investment in technology transfer Projects. In the UK, companies can benefit from reduced corporation tax rate on profits that are generated from patented inventions, through a mechanism called the Patent Box [92]. To do this, companies must record the profits attributable to specific IP. This type of scheme ensures that the data is recorded by companies, and companies may be persuaded to share this information with universities or government (confidentially) in return for this benefit.

3. Agree mechanisms to facilitate data collection.

Discussions with senior stakeholder representatives should be followed up by agreeing and drafting new 'standard' clauses for use in grant terms and conditions, research contracts, IP licences and other related agreements. These clauses would oblige the parties to the agreements to strive to gather appropriate data and make it available to the other party and appropriate funders, so that the data could be analyzed by one or more technology transfer stakeholders. In this way data collection would be the default position in any agreement related to technology transfer

4. Design and Implement a pilot study to measure the outcomes of specific Projects.

A pilot study could be set up to test the ability to collect meaningful technology transfer data throughout the lifecycle of a Project. A small group of projects would be selected to test various parameters, with all participants agreeing to collect and share the required information throughout the project, including monitoring the downstream economic benefits, as long as the Project is active. The ease with which the information is gathered, and its usefulness, will inform the design of new frameworks to measure technology transfer activity and, if necessary, can guide the drafting of new facilitating rules or legislation.

3.9. Intervention S3. Improving Measurement of Technology Transfer

The operation and management of this intervention must be characterized by participation from the stakeholders, who alone can enable the determination of what measures are both

[92] See https://www.gov.uk/guidance/corporation-tax-the-patent-box

desirable and feasible. The NTTB will represent the national goals for improvement in this area; however, the terms of reference will be largely dependent on the willingness of the stakeholders to engage with this issue.

3.10. Measurement of TT: Governance & Evaluation.

The solutions for improving the measurement of technology transfer performance must be developed and agreed by the stakeholders, and led by government, preferably via the National Technology Transfer Board (NTTB)

The NTTB should form a TT Performance Committee. The leader (Chair) of the committee would be appointed by the NTTB, ensuring competency, and would be provided with the terms of reference. The Chair will appoint committee members drawn from representatives of all the relevant stakeholder groups (to be nominated by the groups, where possible), including Universities, Research Institutes, Incubators, Start-up companies, SMEs, and Large Enterprises. Advisors to the committee should include government corporate taxation specialists, and a qualified tax accountant, to explore the options and feasibility for official data reporting. The committee may require legal advice to ensure its recommendations are legally compliant.

The work of the committee will be to create a working plan to improve TT measurement and to oversee implementation, which will be carried out by the stakeholders on behalf of the committee.

3.11. Measurement of TT: Financing.

The costs for implementing this solution will be for the appointment of the Chair and of committee members (the majority of which are expected to be volunteers), and for the expenses associated with committee meetings and publication of its findings. The costs related to the Chair of the committee and specialist advisers may be shared between other committees that are described elsewhere in this Report. The resources estimates are shown in Table 1, below.

Table 1. Summary of Resources required to Establish Super TTOs and NTTN assets

Tasks	Resource
Initial Governance Set-up	
National TT Board (NTTB)	0.25 - 0.5x FTE Chair of Board; 0.5x FTE Office Administrator; 0.25-0.5x FTE Advisors
National TT Network (NTTN)	1x FTE Network Manager; 0.5x FTE Office Administrator. Additional office overheads.
Tasks for S1	
S1. Develop Call for funding	Consultation and pre-drafting 1x FTE for 2-3 months
S1. Draft & Complete legal agreement	Legal services 10-15 days
S1. Recruitment	Professional Recruitment Support resource
S1. Super TTO Board	0.25x FTE Chair of Board; 0.5 FTE Office Administrator; 1x FTE Advisors.
S1. Super TTO Staff	Total of 15x FTE based on the following positions 1x Director; 1x Office administrator; 5x Project Managers; 1x Grants Specialist; 2x Market Researchers; 2x Patents Specialists; 1x Licencing Executive, 1x Contracts Specialist; 1x Industry Liaison Specialist. Additional office overheads.
S1. Professional Support	Commercial lawyers, as required, estimate 25-50 days per year IP layers, as required. Estimate 50-100 days per year for portfolio of 15 patent families (cost borne by IP Owners and licensees). Other consultants (e.g. regulatory). Estimate 50 days per year.
S1. Research Stakeholder Scoping Teams	Per Stakeholder: 1x FTE, team leader; 2x FTE other team members (Scoping teams employed by Research Stakeholders).
Tasks for S2	
S2. Portal Database	Set up: 1x FTE for 1-2 months. Ongoing (data entry, maintenance): 0.2 FTE. Various IT skills.
S2. Portal Website	
S2. Portal IT Management	
S2. ISS office	Initial 1x FTE (senior ISS). After 6-12 months additional 2x FTE. Additional office set up and overhead costs
S2. Senior ISS	
S2. Additional ISS	
Tasks for S3	
S3. Committee Expenses	0.2x FTE Chair of committee for 1-2 months (then 0.1x FTE), 0.2x FTE for advisors for 1-2 months (then 0.1x FTE). Note: the resources for this committee may be supplied from S1 if there is sufficient overlap.

Chapter 4. Specific Strategic Elements (D1, D2, D3)

The analysis that was documented in Part 2 of this work identified multiple issues, where specific interventions could potentially be taken by the Government of Portugal, and/or other major stakeholders, in order to improve the functioning of technology transfer in Portugal[93]. The previous Chapter in this document describe the strategic goals and complex interventions that could be made to achieve those goals (Chapter 3). This section describes the outlines of three (3) proposed discrete interventions (D1, D2 and D3) and relevant background information.

D1 - development and implementation of a technology transfer 'toolkit'.
D2 - support for a national TTO conference in Portugal.
D3 - annual Portuguese TTO data collection.

These discrete interventions have been identified separately from the complex interventions because they have the potential to enable more rapid performance improvements in certain technology transfer functions than the complex interventions (by virtue of shorter timelines). By definition, discrete interventions are more focused and therefore more limited in scope than the complex interventions; however, they could be enacted as either 'stand alone' or as integrated elements within the broader, complex interventions.

In all three cases, these interventions are likely to require national government leadership to implement them, due to their overarching nature, and it is likely that ANI's mandate and resources would make it the most suitable government agency to undertake this.

[93] 'International Benchmarking of Portuguese TTOs' - Part 2 report for this work.

4.1. Development & Implementation of a TT 'Toolkit' (D1).

In Portugal the feedback from TTOs and companies indicates that the process of creating agreements between research and industry is problematic, including the creation of acceptable research contracts and IP licence agreements (for details see Part 2, Chapters 3 and 4). Therefore, the provision of effective tools to assist in this area is likely to have a positive impact on technology transfer performance.

The research which was presented in Part 2 also shows that other countries have developed useful technology transfer 'toolkits' that are made freely available to TTOs and companies, and has suggested that these 'toolkits' are being used successfully. The toolkits consist of practical guides to intellectual property, including patents, and a range of template legal agreements that can be used as starting points to develop final documents. Further comments from Portuguese TTOs and companies suggested that if a similar resource was available in Portugal it would be taken up, and could therefore be used to accelerate the completion of technology transfer agreements by reducing negotiating time and the need tor expensive legal expertise, and by improving the understanding that both parties have for each other's goals (see Part 2, Chapter 3).

There are very good examples of technology transfer toolkits that have been devised and implemented in other countries. The best example is the Lambert Toolkit which was created at the request of the UK Government. The Lambert Toolkit has also inspired other similar projects, such as the Irish Government's KTI model agreements and practical guides, and the Danish Government's 'Johan Schlüter Committee Model Agreements' [94]. The Lambert Toolkit and the KTI resources are described in detail below:

The Lambert Toolkit

The Lambert Toolkit of university and business collaboration agreements is a set of decision tools and standard agreements that were designed to improve the process of negotiating collaboration agreements between research establishments and business; the toolkit was launched in 2005. It followed an independent review of Business-University Collaboration carried out in 2003 by Sir Richard Lambert, who later became Director-General of the Confederation of British Industry (CBI). Lambert was asked by the UK government's Treasury (HMT) to explore the opportunities arising from changes in business R&D and university attitudes to collaboration, and to highlight successful methods of collaboration between universities and industry, including

[94] See The Johan Schlüter Committee Model Agreements: https://ufm.dk/en/research-and-innovation/cooperation-between-research-and-innovation/model-agreement

small- and medium-sized enterprises (SMEs) [95]. The aim was to produce a compromise approach that was fair and balanced, without favoring either industry or university interests, to:

- facilitate negotiations between potential collaborators
- reduce the time and effort required to secure agreement
- provide examples of best practice

The key to the success of the agreements was that the development included discussions between three key parties - The Association for University Research & Industry Links (AURIL) - which was the UK tech transfer association at the time, the Confederation of British Industry (CBI) and the Small Business Service (SBS). In this way, UK research organizations and UK industry representatives were able to reach a compromise position that could be followed by most parties that were attempting to put IP-related agreements in place.

The 'Lambert Toolkit' is available directly from the UK Government's website and includes introductions, and usage guides as well as the actual template agreements themselves [96].

A review of the Lambert agreements in 2013 (after the agreements had been in use for 8 years) found that "the Lambert approach can identify workable solutions to the key issues which arise from contrasting university and industry missions and priorities". However, the review identified continuing barriers to negotiation include IP valuations, organizational bureaucracy in both companies and universities, and a lack of skills of the negotiators on both sides [97].

KTI model agreements and practical guides

In Ireland, KTI (Knowledge Transfer Ireland) has created a suite of model template agreements, inspired by the UK's Lambert Agreements [98] . The resources include advice on how to use the agreements and practical guides to IP and confidentiality that aims to educate researchers, new TTO employees and private company staff on the key principles and processes, and improve confidence [99]. The practical guides were inspired by work done by the University of Manchester [100]. The KTI resources facilitate TTOs and companies to adapt the agreements for their own specific

[95] See https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/311757/ipresearch-lambert.pdf
[96] https://www.gov.uk/guidance/university-and-business-collaboration-agreements-lambert-toolkit
[97] see https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/311757/ipresearch-lambert.pdf
[98] https://www.knowledgetransferireland.com/Model-Agreements/Catalogue-of-Model-Agreements/Overview-to-the-Model-Agreements.pdf
[99] See: https://www.knowledgetransferireland.com/Model-Agreements/Practical-Guides/KTI-Practical-Guide-Managing-Intellectual-Property-Confidentiality.pdf
[100] See: University of Manchester UMIP Intellectual Property & Confidentiality: A Researcher's Guide. https://umip.com/umip-resources/guides-and-booklets/

circumstances, provides information to help develop an understanding of the aims and consequences of the agreement, and the rationale for the various clauses and options. This approach can reduce the requirement for legal advice and accelerate the completion of agreements; therefore, KTI and the Irish Government strongly encourage parties involved in technology transfer to use its model agreements and guides.

The current KTI Model Agreements include these elements:

- various intellectual property licence agreements
- a term sheet for a licence agreement
- a term sheet for a collaborative research agreement
- option agreements
- confidentiality agreements
- material transfer agreements
- a consultancy agreement
- IP assignments
- a head of agreement for Enterprise Ireland Innovation Partnership Programme

4.2. Intervention D1: Develop a Technology Transfer Toolkit for Portugal.

To develop and implement an IP Toolkit, similar in scope to those described above and which is suitable for Portugal, the following actions could be considered:

1. Review the available international model agreements and IP guides that are in use in other countries and identify the elements that would best suit the needs of technology transfer in Portugal. Consolidate these elements into a draft toolkit.
2. Consult with representatives of Portuguese research organizations and industry to review the draft toolkit and introduce any necessary changes or modification (to be agreed by all parties).
3. Seek legal support to ensure that the toolkit is fully adapted for use in Portugal and complies with Portuguese laws and conventions.
4. Make the toolkit freely available and strongly encourage relevant parties to prioritise its use in technology transfer discussions and negotiations.
5. Review the effectiveness of the toolkit, after a suitable period of use (e.g. 2 years) and make amendments based on feedback from its users.

The initial resource for this intervention would be FTE to review and collate the current similar offerings in other countries, and for organization of a committee or working group of TTO and industry representatives to consider the features and options and develop a draft toolkit. Legal advice would be required to develop the draft into legally valid documents that are 'ready to use' in Portugal. Further support and resources would be required to publish the toolkit online, to ensure it is launched with strong, targeted, publicity and that the site is maintained to support good access for the target users.

4.3. Support for a National TTO Conference in Portugal (D2).

The SWOT analysis in Part 2 of this work highlighted technology transfer weaknesses in the areas of networking and staff motivation, and more specifically the lack of a national network where TTO employees can interact, share experiences, learn best practice, or access specialized training (see Part 2, Section 4.3). These weaknesses are likely to contribute to low staff motivation and skills shortages and may contribute to the high levels of TTO staff turnover reported in the ANI TTO survey.

Internationally, annual conferences are held by the major technology transfer associations, which provide valuable opportunities for their members to learn and network. The associations responsible for three of the largest annual TT meetings, ASTP, AUTM and PraxisAuril are profiled below:

ASTP (Association of European Science and Technology Transfer Professionals) is a pan-European non-profit organisation that was established in 2000 by a group of leading technology transfer practitioners [101]. ASTP has approximately 900 members from 45 countries. The purpose of ASTP is to provide training and practice exchange among knowledge transfer professionals. It does this through training courses and events such as the ASTP Annual Conference (which from 27-29 May 2020 will be held in Lisbon). The annual conference attracts around 1,800 professionals from 20 countries; the programme includes lectures and presentations on technology transfer trends and experiences and workshops to disseminate good practices. ASTP has also established its Directors' Forum for knowledge transfer directors; this is a protected space for peer-to-peer advice and problem solving [102].

AUTM (formerly the Association of University Technology Managers) is a U.S.A. member-based organization for technology transfer professionals, with over 3000 members which represent more than 800 organizations, such as universities and research centers [103]. The aims of AUTM are to support their members' work in corporate engagement and intellectual property protection.
AUTM's Annual Meeting for technology transfer professionals attracts US and international delegates who use the opportunity to network, make deals and gain valuable insights from leading technology transfer practitioners and other experts. The annual meeting is supported by partnering software, to maximize the networking potential of the meeting. The meeting also offers training courses on the programme.

[101] See: https://www.astp4kt.eu
[102] See: https://www.astp-proton.eu/member-get-involved/communities/directors-forum/
[103] See: https://autm.net

PraxisAuril is the UK's not-for-profit association for university and public sector knowledge exchange and commercialization professionals. Membership is for organisations (not individuals), and it currently lists 183 member organizations, and it has a distribution list of 5000 individuals. The main activities of PraxisAuril are offering training courses, holding events and promoting best practice for the technology transfer sector. The PraxisAuril annual conference attracts around 300 technology transfer practitioners and industry delegates. The conference has four main themes which are Global KE & Investment, Professional Development, Supporting Impact & Knowledge Exchange, and New Modes of External Engagement.

Smaller national technology transfer organizations such as KTI in Ireland hold annual conferences which are popular and regarded as good networking hubs for technology transfer [104].

In Portugal, the University Technology Enterprise Network (UTEN [105]) held annual conferences which were intended to host discussions around entrepreneurship and technology commercialization, and therefore provided some networking opportunities for professionals working in these areas. However, this conference has not been held since 2013, and UTEN does not appear to have been active since 2016.

4.4. Intervention D2: Set Up a National TTO Conference for Portugal.

Analysis in this report has identified concerns from Portuguese TTOs that there are insufficient opportunities for national-scale networking for technology transfer professionals. Portuguese TTO Staff that are able to access international technology transfer events and conferences (such as those offered by ASTP) find these events important for updating skills, sharing of best practice and improving networks.

It is apparent that if a national conference for technology transfer professionals was established, it is likely to be popular and well-attended. Such a conference could be an excellent platform for sharing experiences and best practices that are relevant to Portugal, and organizing associated training opportunities such as courses and workshops. A successful Portuguese technology transfer conference may also provide additional benefits such as: initiating a 'de facto' national network for Portuguese technology transfer professionals; and, offering an opportunity for a direct interface between technology transfer professionals and Portuguese industry (if companies were to be involved in some capacity) [106].

[104] KTI is a partnership between the Government's Enterprise Ireland agency and the Irish Universities Association.
[105] UTEN is a component of the UT Austin|Portugal Program, working together with the other international partnerships of the Portuguese Foundation for Science and Technology, FCT. See: http://utenportugal.com/events/
[106] It is important that such an event can provide a 'protected' space for TTO staff to interact with each other, therefore any involvement of other stakeholders, such as companies, should be confined to the fringes of the event.

In order to implement this intervention, the following actions could be considered:

1. Review the structure and organization of interesting/relevant technology transfer conferences, and select features from them that will be most relevant to Portugal.
2. Consult with the leaders of Portuguese TTOs to design a national conference that will be useful and attractive to its staff members, and which can offer functionality that is comparable to the other conferences.
3. Seek commitments of support from interested parties (stakeholders) to finance the costs of the conference, and explore other sources of sustainable support such as attendance fees and corporate sponsorship.
4. Launch the conference with the full support of all stakeholders, and strongly encourage all Portuguese TTO staff to attend.

The initial resource for this intervention would be FTE to review other TT events and identify the most useful features, and for organization of a committee or working group of TTOs (volunteers) to consider the features and options and develop a plan for a regular conference. The committee may also act as the initial organizing committee for the conference. Further support and resources would be required to launch a marketing campaign to potential conference delegates.

4.5. Annual TTO Data Collection (D3).

The strategic goals that were described in Chapter 3 Section 3.1, above, call for complex interventions that will effectively re-structure the capabilities of Portuguese TTOs. Such an intervention will require robust monitoring in order to assess its success and to allow targeted modifications as those plans are enacted.

Annual technology transfer data is a useful and informative resource that has been used successfully by governments and agencies in several advanced economies to evaluate performance in this sector, and to identify areas where interventions or structural support should be considered in order to make improvements. In countries such the UK, Australia, Ireland and Denmark, technology transfer activities are reported through highly detailed surveys, which have very high participation rates.

The Higher Education - Business Community Interaction (HE- BCI) survey in the UK is the most comprehensive and detailed survey that is made publicly available, covering 162 UK institutions, and as such provides some guidance for the design of a national annual technology transfer survey

for Portugal [107]. As an example of the level of detail, the UK survey collects data related to intellectual property in the following sub-categories:

IP Disclosures; Patent Applications; Patents Granted; Cumulative Patents Portfolio; Licences Granted to SME (Non-Software); Licences Granted to Other Co. (Non-Software); Non-commercial Licences Granted (Non-Software); Total Licences Granted (non-Software); Total Licences generating income (non-software); Licences Granted to SME (Software); Licences Granted to Other Co. (Software); Non-commercial Licences Granted (Software); Total Licences Granted (Software); Total Licences generating income (software); License Income. SME. Non-Software; License Income. Other Co. Non-Software; License Income. Non-commercial. Non-Software; License Income. Non-commercial. Non-Software; License Income. SME. Software; License Income. Other Co. Software; License Income. Non-commercial. Software; License Income. SME. Other IP; License Income. Other Co. Other IP; License Income. Non-commercial. Other IP; Subtotal IP income; Sale of shares in spin-offs; Total IP revenues; Total costs.

The distinctions that are made between software/non-software and commercial/non-commercial licences can eliminate any distortion of the data due to large numbers of 'free' licences.

The next most comprehensive national annual technology transfer survey is published by KTI for Ireland. In 2018 This survey identified data from 25 out of a total of 26 Irish TTOs (96%) [108]. However, he KTI survey does not publish the LOA revenues that are received by individual TTOs, only consolidated data for the TTOs associated with the three classes of Research Performing organisations (RPO) being, universities, institutes of technology and state and specialist research institutes. The survey also provides only consolidated data for 'active' LOAs (the agreements that generate the revenues reported in the survey year).

The previous survey that was conducted by ANI, and which formed the basis of Part 1 of this work, provided significant technology transfer data coverage and is an excellent base from which to build an annual Portuguese technology transfer data survey. In particular, the survey has delivered robust data for characterising TTO staff skills, qualifications and turnover, TTO budgets, Patent portfolios, and LOA and spin out activity. One of the disappointing aspects of the survey results was the partial lack of responses from the participating TTOs, particularly in the area of LOA and spin-off activity, therefore strategies to increase participation rates could make it more valuable.

[107] See: https://www.hesa.ac.uk/data-and-analysis/business-community
[108] see: https://www.knowledgetransferireland.com/Reports-Publications/KTI-Review-and-Annual-Knowledge-Transfer-Survey-2018.pdf

Additional data categories could be considered, which may increase the effectiveness of the survey as a tool to measure technology transfer performance in Portugal. These suggestions are made in the light of the analysis performed in Part 1 and Part 2 of this work and, in particular, the evaluation of data collected in Portugal's peer group of countries. These categories are:

- IP/Patents: 'Invention Disclosures'; 'Number of Patent Families in the Patent Portfolio'.
- Income: 'Institutional Research Funding'; 'Income from Research Contracts'
- LOAs: 'Software' and 'Non-Software' LOAs; 'Commercial' and 'Non-Commercial' LOAs; 'Total Active LOAs'. [109]
- Spin-Offs: 'Number of Spin-Offs generating revenues'; 'Spin-Off Turnover'; 'Spin-Off Turnover Attributable to Institute's IP'; 'Institution's Equity Ownership Position in the Spin-Off'; 'Revenues Received by the Institution'.

4.6. Intervention D3: Design and Implement an Annual TTO Survey.

There is good evidence to suggest that a national survey of technology transfer activity in Portugal, along the lines that have been established in other countries (and comparable to the ANI survey), could be beneficial for the management and development of TTO activities in the country.

In order to implement this intervention, the following actions could be considered:

1. Review the leading technology transfer surveys, that have relevance to the Portuguese economy, and create a draft questionnaire that includes questions designed to gather data in all the desirable categories.
2. Discuss the draft questionnaire, and mechanisms to ensure high participation rates, with stakeholders (TTOs, Universities, Research Institutions, Government). Agree a final version, suitable for release.
3. Determine the protocols for effective distribution of the questionnaire and identify an agency that will have responsibility for distribution, collecting returns, curating and publishing the data, and conducting regular reviews.
4. Launch the questionnaire.

[109] In addition a category should be considered to capture the total downstream value created by LOAs, which has been discussed in more detail in Section 3.8, above.

The resource for this intervention would be FTE to draft an updated TTO questionnaire, and for organization of a committee or working group of representatives from TTOs, Universities, Research Institutions, and Government (all volunteers) to consider the new version of the questionnaire and the strategy for implementing it. 'Downstream' FTE and data management resources will be necessary to enable the collection, processing and storage of the survey data, and to analyze, summarize and publish it on an annual basis.

4.7 Outline Resources & Costs for the Three Discrete Interventions.

A summary is shown below of the potential resources that would be required to implement the three discrete interventions described above. There are, potentially, some significant overlaps in the resources required for all 3 interventions (whereby FTE could be shared between tasks) however these tasks are described separately.

Table 2. Tasks & Resources Required for D1, D2, D3.

Tasks	Resource
D1: TT TOOLKIT	
D1. Review toolkits	0.5 x FTE. Experienced in TT practice (2-3 months)
D1. Organise and lead toolkit working group	0.1 x FTE. Committee experience. (6 months), then 0.1 x FTE (after 6 months)
D1. Evaluate toolkit performance	0.1 x FTE (in year 2 and thereafter). Experienced in TT
D1. Manage toolkit publication and enquiries	0.1 x FTE. Web and data competence
D1. Finalise toolkit	Legal services (estimate 5-15 days).
D1. Set up and operate website	Website development and hosting services.
D2: NATIONAL TT CONFERENCE	
D2. Review conferences	0.5 x FTE. Experienced in TT practice (2-3 months)
D2. Organise and lead conference working group	0.1 x FTE. Committee experience. (6 months), then 0.1 x FTE (after 6 months)
D2. Evaluate conference performance	0.1 x FTE (in year 2 and thereafter). Experienced in TT
D2. Manage conference publicity and registration	0.1 x FTE. Web and data competence

Tasks	Resource
D2. Conference logistics	Private conference management team. (estimate 5 days plus costs)
D2. Conference venue	Venue hire.
D2. Set up and operate website	Website development and hosting services.
D3: ANNUAL TTO SURVEY	
D3. Review survey	0.5 x FTE. Experienced in TT practice (2-3 months)
D3. Organise and lead Survey working group	0.1 x FTE. Committee experience. (6 months), then 0.1 x FTE (after 6 months)
D3. Evaluate Survey performance	0.1 x FTE (in year 2 and thereafter). Experienced in TT
D3. Manage Survey logistics and data	0.1 x FTE. Web and data competence
D3. Survey data storage	Secure server
D3. Set up and operate website	Website development and hosting services.

Chapter 5. Implementation Strategy Features

The interventions described in the previous two chapters (Chapter 3 and 4) will require careful preparation to ensure that their implementation will result in good uptake and realization of the planned improvements. The strategic goals described in Chapter 3 and the associated interventions must be sensitive to the *status quo* of the stakeholders and specific circumstances that may influence acceptance and success. Potential implementation issues for selected interventions are described below.

5.1. Implementation Strategy for Intervention S1 (Super TTO).

The 'Super TTO' model that has been described, will have significant advantages for its stakeholders that should make it a valuable option, such as more efficient operations (shared between stakeholders), access to broader technology transfer capabilities and facilities, and the creation of more stability and better staff motivation. However, the adoption of this model will require some cultural changes that may be resisted, such as the requirement to delegate authority for technology transfer to an 'arm's length' organization over which there would be much less control than the current set-up, and the need to co-operate with other stakeholders that may be regarded as competitors. Therefore, the implementation strategy may require some specific features to counter this resistance, as described below:

1.Self-organization -The establishment of Super TTOs should be initiated as a 'call for proposals' whereby the stakeholders of existing TTOs are invited to organize themselves into viable groups alongside collaborative organizations, and propose their own structures and budgets (within the limits allowed by the model). This approach would have the advantages of allowing the stakeholders to develop practical and feasible relationships and budgets, that should minimize the risk that transition to a 'Super TTO' would be regarded as an imposition or that it would be a disadvantage for any of the stakeholders.

2.Pilot Project- Higher education and research organizations may not to choose to embrace the transition to Super TTOs due to the simple perception that all change is risky and that maintaining the *status quo* is therefore a safer option for their organization. Therefore, an exemplary Pilot Project could demonstrate the advantages of Super TTOs to the stakeholder community and help to convince them to participate. For the Pilot Project, ANI would invite selected organizations to participate, and invest significant effort to manage the set-up process; it would be advantageous

to select the best organizations to demonstrate the model, and in particular those that are ranked very strongly for research excellence and research translation. The Pilot Project's technology transfer Team should be drawn from technology transfer professionals with a strongest possible track record of success.

5.2. Implementation Strategy for Intervention D2 (TTO Conference).

The success of efforts to establish a national TTO conference will rely on patronage and attendance by individual technology transfer workers. In order to ensure that attendance is sufficiently high to be effective, the conference should be hosted by an organization that is independent of the stakeholders and represents the interests of its staff. Formation of a Portuguese national technology transfer association should be supported by ANI to fulfil this role. Such an association should be independently organized and managed by technology transfer staff, in order to provide a sense of community, but it is likely to require financial support to begin with. The membership should reside with individuals, who would pay (subsidized) annual subscription fees to provide a sense of ownership. The community aspect of the association would attract members to the conference, but it would also provide some stability and support when staff are in transition between jobs, improving motivation and encouraging staff to stay within the TT sector.

APPENDIX

Abbreviations used in this report

ANI - Agência Nacional de Inovação

FTE - Full-time equivalent (worker)

IP - Intellectual property

ISS - Industry support specialist

LOA - IP licence, option or assignment agreements

NTTB - National technology transfer board (proposed)

NTTN - National technology transfer network (proposed)

POC - Proof of concept

R&D - Research and development

RPO - Research performing organization

SME - Small- and medium-sized enterprises

SWOT - Analysis of strengths, weaknesses, opportunities and threats.

TT - Technology transfer

TTO - Technology transfer organization