what works centre for
local economic growth

Toolkit

Supporting University Spin-offs

What are they and what do they aim to do?

University spin-offs are business ventures founded by academic staff to commercially exploit academic research.

Spin-offs can strengthen the linkage between universities, industry and the local economy (the "Triple Helix") and are one way in which university research may have a significant impact on local economic development.[1] Proponents of supporting university spin-offs argue that they are flexible and dynamic, playing an important role in the introduction of new-to-the-market products and the development of high-tech clusters. Others urge caution, because of the standard concerns around non-market interventions in innovative activities (e.g. universities supporting academics to create spin-offs may crowd out private sector entrepreneurship) and because of unintended consequences on universities themselves (e.g. encouraging spin-off activity may remove resources from basic research).

1 For two examples of recent papers on the economic impact of universities are e.g. Hausman N. (2012), "University Innovation, Local Economic Growth, and Entrepreneurship", US Census Bureau Center for Economic Studies Paper No. CES-WP- 12-10; Valero A., Van Reenen J. (2016), "The Economic Impact of Universities: Evidence from Across the Globe", NBER Working Paper No. 22501. For two examples looking at local impacts see Guerrero Maribel, James A. Cunningham and David Urbano. 2015. "Economic impact of entrepreneurial universities' activities: An exploratory study of the United Kingdom". Research Policy, vol. 44(3): 748-764 and Iacobucci Donato and Alessandra Micozzi. 2015. "How to evaluate the impact of academic spin-offs on local development: an empirical analysis of the Italian case". The Journal of Technology Transfer, vol. 40(3): 434-452. Maribel et al. (op sit) provide an extensive list of other studies.

This toolkit does not address these bigger picture questions. Instead, it summarises the available empirical evidence on two key decisions that can affect the number and performance of university spin-offs:

1. the rules which govern whether the university or researcher owns (more of) the intellectual property rights and the broader set of incentives provided to academics
2. the ways in which universities support technology transfer, including through dedicated offices (TTOs). The set of studies that consider these issues also consider the way in which different university or area characteristics affect spin-offs.

Although not our focus, we also summarise those findings.

Things to consider

- **Can changing the rules governing intellectual property increase the number of spin-offs?** The evidence on who should own Intellectual Property Rights (IPR) and what good rules look like is inconclusive, so any changes to intellectual property rights will need careful monitoring and evaluation to establish the effect on spin-offs and other activity.
- **Is university-provided entrepreneurial support effective in promoting academic spin-offs?** Again, the evidence is mixed. Universities investing in TTOs will need to monitor and evaluate performance - both in terms of introduction of the support but also when considering changes to support (e.g. increasing TTO size). The same holds for other schemes (e.g. to provide equity or limit entrepreneurial risk).
- **What's the role of university-industry collaboration and different funding sources?** Collaboration may have a positive effect on spin-offs, but the evidence is less clear on the appropriate funding mix. There is some evidence that private sector funding may reduce spin-offs – possibly because collaborating firms use any resulting innovations directly. This raises an interesting question about whether spin-offs (as opposed to other forms of university-industry collaboration) are the best way to facilitate knowledge transfers to the local economy.
- **Should policy that supports spin-offs target particular types of universities?** Again, the evidence is inconclusive which highlights the importance of monitoring and evaluating the impact of different support schemes.

How effective are they?

There are more studies addressing elements of spin-off policy design than we typically find for our toolkits – 17 studies met our toolkit requirements, two from the UK. However, the variety of design elements and objectives covered by these studies, combined with the inconclusive nature of many of the findings, means that we can offer little guidance as to what works best in this area.

The evidence is inconclusive on whether university or researcher ownership of IPR is better for spin-offs. Two studies find that allocating IPR to researchers increases the number of spin-offs [1,2]. Two studies [3,4] find the opposite (i.e. a positive effect of allocating IPR to universities).

The evidence is mixed on whether TTOs increase spin-offs: three studies [6, 7, 8] find positive effects on the number of spin-offs while two find no effect [3, 5]. One study [9] finds positive effects for the number of spin-offs but negative effects on the 'quality' (the proportion of spin-offs that receive first round VC funding).

The evidence is also mixed on whether TTO size, experience or specialisation increase spin-offs: five studies find that size has a positive, although less than proportionate, effect on the number of spin-offs [1, 6, 8, 10, 11], three find no effect [12, 13, 14]. Two find positive effects for experience [7, 9], two find no effect [10, 14]. One study finds positive effects for specialisation [11], another finds no effect [10].

The evidence is mixed on other things universities do to directly support spin-offs: two studies suggest clearer university rules on spin-offs might help with the number of spin-offs [2, 10] but one of these cautions that this is only if rules are not too strict [2]. One study finds positive effects of university equity policies, but not access to venture capital [4]. Another suggests that reducing entrepreneurial risk has no effect [2].

University-industry (U-I) partnerships may have a positive effect on spin-offs: the two studies that consider university-industry collaboration both find evidence of positive effects on the number of spin-offs [14, 15]. A third study [16] shows that geographical proximity of new start-ups to the parent university (which may facilitate collaboration) increases the number of innovative products and patents.

Public funding may have a positive impact on spin-offs and vice-versa for private funding. Two studies [7, 17] find a positive effect of public sector finding on the number of spin-offs. In contrast one study finds a negative effect of private sector funding [17], while two more find no effect [4, 7].

The evidence is mixed on whether university patenting activity and eminence increases spin-offs. Two studies find positive effects of patent activity [6, 11] on the number of spin-offs, one no effect [7] and one negative effect [13]. Three studies [4, 5, 9] find that more eminent universities (measured by the number of graduate staff and quality of research) increase the number of spin-offs. However, two studies [7, 14] find no effect.

The size of a university may increase spin-offs. Two studies [10, 17], find that the size of the university measured by the number of faculty members seems to increase spin-offs (although only one of these is clear that the effect is more than proportionate).

Are spin-offs cost effective?

There is very limited evidence on the overall economic benefits of spin-offs on local economies. None of the studies provides a discussion of the cost-effectiveness of specific interventions which might increase the number or quality of spin-offs.

Annexe: evidence on university spin-offs

How secure is the evidence?

This toolkit summarises the available empirical evidence on the effect of several policies, initiatives and funding in supporting academic spin-offs. This toolkit does not consider evidence based on qualitative or case study methods but focuses instead on econometric evaluations that identify the causal effect of the public support provided. We have mostly looked for evidence on university spin-off, spin-out and academic entrepreneurship. We focused on academic papers and policy reports from OECD countries, in English.

We considered any study that provided before-and-after or cross-sectional evidence that controls for differences between (for example) start-up activity from universities versus those in the wider economy, or (for example) performance measures of those two groups of start-ups. We also included more robust studies that compared changes with a control group, or that used a source of randomness to estimate a causal effect.[2] Throughout the toolkit, we have placed greater emphasis on studies with stronger and more robust econometric methods. Using these criteria, we found 17 studies that looked at the support for spin-offs and that met our evidence standards. We scored nine of these as SMS2 while eight were scored as SMS3.

These studies provide evidence on two key decisions that can affect the number and performance of university spin-offs:

- the rules which govern whether the university or researcher owns (more of) the intellectual property rights (IPR) and the broader set of incentives provided to academics; and
- the ways in which universities support technology transfer, including through dedicated offices (TTOs). The set of studies that considers these issues also considers the way in which different university or area characteristics affect spin-offs. Although not our focus, we also summarise those findings.

Almost all the studies have used university-level spin-off data, while one of them complemented the analysis using researcher-level data. Most of the studies focused on Italy (8), the US (3) and the UK (2). The remaining contributions used data on Germany (2), Canada (2), Norway (1), Spain (1) and the EU as a whole (1).

The evidence

The evidence is inconclusive on whether university or researcher ownership of IPR is better for spin-offs. Two studies find that allocating IPR to researchers increases the number of spin-offs [1,2]. Two studies [3,4] find the opposite (i.e. a positive effect of allocating IPR to universities).

Study 1 (SMS2 – university) evaluates the impact of organizational incentives on university–industry technology transfer in the US using data from Technology Transfer Offices filed by directors of 113 academic institutions for 1991-1998. The study looks at commercial knowledge transfers from universities to practitioners or university/industry technology transfer (UITT) usually via licensing agreements, research joint ventures, and start-ups. The study focuses on the effect of three factors (invention disclosures, number of TTO employees and external legal expenditures) on licensing agreements. The main outcomes of interest are (the log of) the average annual number of licensing agreements and associated revenues. As explanatory factors, the study considers (average annual) invention disclosures, TTO employees and external legal expenditures, as well as quadratics and interactions of these three factors. Their empirical model is based on a production frontier function with a stochastic error term which includes the usual random component and deviation from the frontier (modelled parametrically as a function of

2 See the Maryland Scientific Methods Scale (SMS) http://www.whatworksgrowth.org/resources/the-scientific-marylandscale/.

environmental, institutional and organizational variables). The parameters are estimated using maximum likelihood. Universities that allocate a higher share of royalty payments to faculty members, tend to be more efficient in technology transfer activities – as measured both by the average annual licensing numbers and revenue. The study also suggests that increasing the number of TTO staff increases the number of licensing agreements, but not revenues while increasing the use of outside lawyers has the opposite effect (fewer agreements, more revenues).

Study 2 (SMS3 – university) evaluates the effect of university rules governing the creation of spin-offs on the number of spin-offs from Italian universities, focusing on the period 2005-2012. The main outcome of interest is the annual number of academic spin-offs for a given university. As the main explanatory factors, the study considers general rules and procedures (specific regulations on spin-off creation, research contracts, predefined guidelines for business plans, pre-established conflicting activities, evaluation committee of spin-off proposals), monetary incentives (minimum equity share held by researchers, share of revenues for the university, part-time working schedule for spin-off promoters, amount hold by the university due to patenting), and entrepreneurial risk (maximum limit on research contract, not sharing spin-off losses). The study estimates a negative binomial model and controls for other factors such as stock of prior spin-offs, number of prior patents, research funds from contract and consultancies in the past, total government research funding (lagged), presence of TTO, number of research staff, if the university is a polytechnic, the university's rank, and some characteristics of the region. The presence of a regulatory framework for spin-offs increases spin-off creation, as does the availability of some form of monetary incentive for researchers. Consistent with this, overly-restrictive university rules regarding research compensation from contract research and consulting activities have a negative effect on the number of spin-offs. Finally, whether and how universities mitigate entrepreneurial risk (e.g. by limiting individual losses) appears to have no effect.

Study 3 (SMS3 – university) analyses how entrepreneurial support and the ownership of patent rights influence academic start-ups using data on German universities from 1995 to 2008 and exploiting an exogenous change in University-Industry (U-I) laws introduced in 2002. The laws set up new infrastructure to facilitate university-industry technology transfer (in the form of 29 regional 'Patent Valorization Agencies') as well as expanding Federal subsidies to university-specific Technology Transfer Offices (TTOs). At the same time, it shifted the ownership of patent rights from university researchers to their universities. The authors use a difference-in-differences setting where the treated group is defined as university investors (affected by the law) and the control group are researchers belonging to public research organisations which already have a strong TTO infrastructure. The main outcome of interest is the number of academic start-ups. The study uses a Poisson quasi-maximum likelihood estimator including fixed effects at the researcher level. The study finds no evidence that the new infrastructure or additional support to TTOs resulted in an increase in academic start-ups. The shift in patent rights increased the percentage of patents that translate into spin-offs but decreased the volume of patents, with the largest decrease taking place in faculty-firm patenting. The study suggests that the relative size of the different effects likely decreased overall technology transfer but is unable to provide an estimate of the overall effect.

Study 4 (SMS3 – university) investigates the role of different university characteristics in explaining US university spin-offs. The study uses data on cross-institutional variation in new firm formation rates and several different explanatory factors obtained from university technology licensing offices (TLOs) over the 1994–1998 period. The main outcome of interest is the count of the number of TLO start-ups for each university in a given year. As explanatory factors, the study focuses on measures of venture capital availability;[3] the share of sponsored research budget (industry funded) by university in a given year; measures of intellectual eminence;[4] and university licensing policies.[5] The study estimates a negative binomial model using generalized estimating equations (GEE). The results suggest that university licencing policies can affect start-ups. Universities that take up equity stakes in licensees have nearly double the start-up rate. In contrast, increasing the inventor's share of royalties by 10% decreases start-ups by

3 The number of local companies receiving venture capital funding from investors in a given year and the amount of that funding; the number of local venture capital funds in a given year and the amount of that funding. For all variables local is defined as within 60 miles of each university.

4 Overall academic rating score of graduate schools published in the Grouman Reports.

5 The investor share of royalties, whether the TLO could make an equity investment in TLO start-ups, whether it has access to technology incubators, and whether universities were permitted to make venture capital investments in licensees of university technologies.

almost 20%. More eminent universities have more start-ups, but the commercial orientation of research has no effect. Finally, the study finds no evidence that the availability of local or university venture capital, or the presence of a university-affiliated incubator, influences the number of start-ups.

The evidence is mixed on whether TTOs increase spin-offs: three studies [6, 7, 8] find positive effects on the number of spin-offs while two find no effect [3, 5]. One study [9] finds positive effects for the number of spin-offs but negative effects on the 'quality' (the proportion of spin-offs that receive first-round VC funding).

Study 3 (SMS3 – university) discussed above finds no evidence that the new infrastructure or additional support to TTOs resulted in an increase in academic start-ups.

Study 5 (SMS2 – firms) explores the role of university-industry relationships in affecting the location of innovative start-ups in Italy using data from start-ups registered between 2012 and 2014. The main outcome of interest is the distance from a given spin-off to the closest university. For the explanatory factors, the study considers quality of the university's research and human capital as well as third mission data (collaboration agreements, number of patents, incubators, consortia, archaeological sites and museums) which come from an Italian research quality evaluation for the period 2004-2010; spin-off characteristics; and controls for characteristics of the region. The study analyses how distance from a start-up to the closest university is affected by these university characteristics and other factors using a regression framework. The number of graduates and the quality of research both have a positive effect (i.e. they reduce distance) but third mission variables have no effect. Some location characteristics also play a role.

Study 6 (SMS2 – university) analyses the extent to which University-Level Support Mechanisms (ULSMs) increase spin-offs using data on 64 Italian universities for the period 2000-2007. The outcome of interest is the annual number of academic spin-offs by university. The study considers three main groups of explanatory factors. First, university characteristics such as university size (total number of faculty members), entrepreneurial eminence (number of spin-offs prior to 1999 and the cumulative number of spin-offs after 1999), patenting activity (stock of patents); funds from public entities. Second, ULSMs proxied by university incentive structures to participate in external commercialization activities. The third group considers regional variables which are linked to social capital. The study estimates a multi-level Poisson model, which allows for university-level fixed effects to control for unobserved heterogeneity, and in some specifications also allows for random coefficients (intercepts and slopes) at the region level. ULSMs (including the previous number of spin-offs, external collaborations, patent regulations, the existence of a TTO, and TTO affiliation to external networks) are positively correlated to spin-offs. Unfortunately, the study considers each of these, in turn, so we can't be confident about the importance of any specific aspect. The study also looks at heterogeneity depending on local context (including a regional social capital index, financial development index, regulations, governmental R&D expenditure and support to high tech enterprises). It suggests that the effects of ULSMs are larger in regions with more support for high tech enterprises, while the higher values for the other regional variables decrease the effects of ULSMs. The random-effect modelling adopted by the study makes these results a little difficult to interpret.

Study 7 (SMS3 – university) investigates multiple factors that might affect the number of academic spin-offs from Italian universities using data from 2005 to 2011. The main outcome of interest is the annual number of academic spin-offs by university. The study considers several explanatory factors such as the presence of technology transfer offices, the stock of academic and non-academic spin-offs before 2005, public funding perceived by the university, commercial income, number of patents, university size, and indicator for southern region, and the total number of publications. Due to the count nature of the dependent variable and its high share of zeros, the study estimates a zero-inflated negative binomial model. Public funding increases the number of spin-offs, but private funding has no effect. The presence of a technology transfer office (TTO) and a university's past experience in creating spin-offs also have positive effects. In contrast, measures of university scientific productivity and previous patenting experience (both at the university and regional level) have no effect.

Study 8 (SMS2 – university) analyses the effect of several factors on patenting, contract research and spin-offs using data on 105 European universities using survey data from 2003. The study considers three main outcomes of interest: the number of patents, research contracts, and spin-offs created by a university. For explanatory factors, the study considers size of the university (number of academic staff), disciplines within the university (Arts and Humanities, Engineering, Science, Life Science), number of scientific publications (relative to number of academic staff), regional expenditures on R&D, and TTO size (total number of staff). The study estimates a linear regression model using OLS. The results for spin-offs suggest that the size of technology transfer offices has a positive effect. The study also finds a positive effect for area level R&D expenditure, as well as presenting some evidence of complementarities between the different transfer mechanisms (although these results are a little hard to interpret).

Study 9 (SMS3 – university) evaluates the impact of national changes in IPR and the establishment of university-specific TTOs on the quantity and quality of spin-offs, using data on the population of universities in Italy, Norway, and the UK, for the period 2000-2012. The two main outcomes of interest are simple spin-off counts ('quantity') and the proportion of spin-offs that receive first-round VC funding ('quality'). As explanatory factors, the study includes changes in the IPR institutional setting and a binary indicator that takes the value of one whenever a TTO is established in a given university and a given year. The study estimates a negative binomial model also controlling for country-specific time-varying factors (i.e. GDP per capita, unemployment rate; VC availability) and time-invariant factors; university level controls such as size, foundation year, sponsored research expenditure, experience with technology transfer activities, stock of spin-offs; age of prior spin-offs, university eminence, university fields of research, and presence of high-tech firms. The results for the national variable – which simply measures the number of changes in IPR over the time period – are hard to interpret. Quantity goes up while quality goes down, but it is unclear what the variable is capturing (the authors suggest universities may be creating spin-offs simply to signal compliance with changes in policy, rather than investing in developing strong companies). The direction of the effect is similar for the easier-to-interpret TTO variable: spin-off creation is 20% higher for universities with TTOs; around 30% fewer spin-offs receive first-round VC but this effect is only marginally significant. Results also suggest that TTO experience (measured by the cumulative number of spin-offs) and university eminence (based on a national ranking) positively impact spin-off quantity, but not quality.

The evidence is also mixed on whether TTO size, experience or specialisation increase spin-offs: five studies find that size has a positive, although less than proportionate, effect on the number of spin-offs [1, 6, 8, 10, 11], three find no effect [12, 13, 14]. Two find positive effects for experience [7, 9], two find no effect [10, 14]. One study finds positive effects for specialisation [11], another finds no effect [10].

Study 1 (SMS2 – university) discussed above finds evidence that increasing the number of TTO staff increases the number of licensing agreements.

Study 6 (SMS2 – university) discussed above finds evidence that the number of individuals in TTO trained by NETVAL (Network for the Valorisation of University Research) is positively correlated with the number of spin-offs.

Study 8 (SMS2 – university) discussed above finds evidence that the size of technology transfer offices increases spin-offs.

Study 10 (SMS2 – university) analyses the effect of several factors on contract research (licensing and R&D) and spin-offs using data from 52 Spanish universities from 2001 to 2005. The study considers five outcome variables at the university and year level: (the logarithm of) income derived from R&D contracts and licensing, as well as the number of both; and the number of spin-offs. The main explanatory variables include university policies linked to technology transfers if there is a science park, TTO size (number of employees), experience (TTO age), and specialization in R&D contracts (share of specialized employees). The study uses linear regression analysis also controlling for various university characteristics (e.g. 'quality', public university), region and year fixed effects to account for unobserved (time-invariant) heterogeneity and aggregated shocks, respectively. A negative binomial model is estimated for count variables. The study finds that the size of the technology transfer offices has a positive effect on the creation of spin-offs, but that experience and a spin-off 'specialism' have no effect. Established policies and procedures for the

management of technology transfer (e.g. rules on participation, conflict of interest, copyright, invention disclosure, academic leave) and programmes to support spin-offs and provide venture capital are all positively correlated with spin-offs. Unfortunately, the study considers each of these in turn, so we can't be confident about the importance of any specific aspect. The various controls for university characteristics don't seem to play much of a role.

Study 11 (SMS2 – university) considers the role of university policies and university technology transfer units (TTO) in creating spin-offs, using data on 43 Italian universities from 2003 to 2005. The main outcome of interest is the annual number of spin-off companies by university. For explanatory factors the study considers the network size of TTOs (the number of different external organisations with which TTO interacts such as science parks, incubators, tech transfer organisations, banks, etc) the network strength of TTOs (measured by the frequency of interactions between the TTO and other external organizations); the number of employees supporting technology transfer activities; the number of services offered by TTOs, as well as other complementary services. The study also controls for other variables such as the number of patents, the university location, and the presence of offices involved in TTO activities. The study uses regression analysis for (the logarithm of) the number of spin-off companies created and also estimates a negative binomial and Poisson model when using spin-off counts. The results suggest that the number of spin-offs is positively related to the size of the TTO, the number of services it provides (identifying technological opportunities, support in business plan development, patenting or funding) and the availability of other complementary university services (university-affiliated incubator, spin-off regulation, business plan competition). Results on the importance of ties to external organisations are mixed. University location also appears to play a role.

Study 12 (SMS3 – university) analyses the effect of university characteristics on spin-offs using data from 85 Italian universities from 1999 to 2013. The main outcome of interest is the number of spin-offs for a given university and a given year. For explanatory factors, the study focuses on the impact of 'excess' administrative staff measured as the actual number of administrative staff to the number that would be predicted based on university characteristics. The study estimates a negative binomial model controlling for characteristics of the region and other university characteristics. The study finds no effect of TTO size and no effects from several other university characteristics (e.g. faculty/student ratio, STEM faculty ratio, publications per faculty). 'Excess' administrative staff has a positive relationship with technology spin-offs and a U-shaped relationship with non-technology spin-offs (although these results are a little hard to interpret).

Study 13 (SMS3 – university) looks at the impact of the introduction of nationally assessed university performance metrics, on university spin-offs using data from 1999-2015 from 85 Italian universities. Since 2004 research performance and its economic 'valorization' (measured through patents, spin-offs, etc) have determined the allocation of research funding, and the study uses this change to look at the impact on spin-offs. The main outcome of interest is the number of spin-offs for a given university and a given year. The main explanatory factor is the introduction of the metrics performance-based research funding system (captured by a dummy that takes the value of one after 2003). The study estimates a negative binomial model including fixed effects and including other time-varying controls such as publication per faculty, number of patents at the university level, rank of the university, ratio of PhD students and open positions for assistant professor at the regional level, ratio of highly educated and unemployed-total number of unemployed, university size, university fields of research, TTO size, and characteristics of the region (GDP, patenting activity, number of graduates, and R&D expenditure). Introduction of these new metrics of assessment increased the number of academic spin-offs. The increase in spin-off creation occurred mainly in regions with higher skilled unemployment and in universities with fewer academic career opportunities, rather than in more research-oriented or more prestigious universities. The study argues that this pattern of results suggests the metrics promoted spin-offs as a response to a lack of labour market opportunities, rather than via technology transfer. Results also suggest that university patenting activity is negatively related to spin-offs (although this result is not particularly robust) while TTO size has no effect.

Study 14 (SMS2 – university) investigates the impact of university–industry R&D collaboration on university technology commercialization for 82 leading US and Canadian universities for the period 2006-

2009. The main outcome of interest (university-industry co-publications; UICP) is computed as the number of publications with at least one author in academia and one author in the private sector divided by the total university publications within a year. The study considers three outcome variables: the number of patents, the number of patents weighted by quality, and the number of spin-offs. The study uses a linear regression analysis controlling for measures of research quality and quantity, as well as university resources devoted to technology commercialization. The number of UICP collaboration projects has a significant positive influence on the number of patents, spin-offs and technology licenses established. Additional results suggest that the size and age of a university's Technology Transfer Office and the quantity and quality of research staff have no impact on the number of spin-offs.

Study 7 (SMS3 – university) discussed above finds evidence that the presence of a technology transfer office (TTO) and a university's past experience in creating spin-offs also have positive effects.

Study 9 (SMS3 – university) discussed above suggests that TTO experience (measured by the cumulative number of spin-offs) positively affects spin-off quantity.

Study 10 (SMS2 – university) discussed above finds evidence that technology transfer office experience has no effects on spin-offs.

Study 14 (SMS2 – university) discussed above finds evidence that the age of a university's Technology Transfer Office has no impact on the number of spin-offs.

Study 11 (SMS2 – university) discussed above finds evidence that the number of spin-offs is positively related to the number of services university provides (identifying technological opportunities, support in business plan development, patenting or funding).

Study 10 (SMS2 – university) discussed above finds evidence that TTO specialism has no effects on the creation of spin-offs.

The evidence is mixed on other things universities do to directly support spin-offs: two studies suggest clearer university rules on spin-offs might help with the number of spin-offs [2, 10] but one of these cautions that this is only if rules are not too strict [2]. One study finds positive effects of university equity policies, but not access to venture capital [4]. Another suggests that reducing entrepreneurial risk has no effect [2].

Study 2 (SMS3 – university) discussed above finds evidence that the presence of a regulatory framework for spin-offs increases spin-off creation. However, overly-restrictive university rules regarding research compensation from contract research and consulting activities have a negative effect on the number of spin-offs. Finally, whether and how universities mitigate entrepreneurial risk (e.g. by limiting individual losses) appears to have no effect.

Study 4 (SMS3 – university) discussed above finds evidence that universities that take up equity stakes in licensees have nearly double the start-up rate. Furthermore, it finds no evidence that the availability of local or university venture capital.

Study 10 (SMS2 – university) discussed above finds evidence that established policies and procedures for the management of technology transfer (e.g. rules on participation, conflict of interest, copyright, invention disclosure, academic leave) and programmes to support spin-offs and provide venture capital are all positively correlated with spin-offs.

University-industry (U-I) partnerships may have a positive effect on spin-offs: the two studies that consider university-industry collaboration both find evidence of positive effects on the number of spin-offs [14, 15]. A third study [16] shows that geographical proximity of new start-ups to the parent university (which may facilitate collaboration) increases the number of innovative products and patents.

Study 14 (SMS2 – university) discussed above finds evidence that the number of U-I collaboration projects has a significant positive influence on the number of patents, spin-offs and technology licenses

established.

Study 15 (SMS2 – university) analyses the role of innovation support infrastructures on university-industry collaboration for university knowledge commercialisation in the UK. The primary data source is the Scopus database from 1975 to 2010, which contains information about scientific publication in journals, books and conference proceedings. The study only considers publications from research and higher education institutions. It carries out a survival analysis conditional on covariates to identify which factors explain the time length between the spin-off creation and the publication (and patenting) of academic outputs. The study also considers other commercial performance measures such as revenues of academic spin-offs. The presence of research active science parks and incubators are positively associated with the commercial performance of universities in terms of the number and revenue of academic spin-offs, other research contracts and licensing, although effects are not large. Strong linkages with these support infrastructures (i.e. facilities are on-site or university-owned) have no additional effect.

Study 16 (SMS3 – firm) considers the differences between innovation capabilities of spin-offs and other knowledge-intensive firms and the factors that might help explain these differences using data from a survey carried out in 2004 of firms located in East Germany. The survey distinguishes between spin-offs from universities (or public research institutes) and spin-offs from other knowledge-intensive firms. The study identifies a total of 121 university related spin-offs and uses matching techniques (propensity score matching, PSM) to find a comparable set of non-research spin-offs. Results suggest that research spin-offs have more patent applications and more radical product innovations than similar firms. This superior innovation performance can be explained by their high level of research cooperation and by location factors: physical proximity to the parent institution is found to be conducive to innovation productivity. Research spin-offs are also more successful in attracting support from public innovation support programmes in comparison to their peers.

Public funding may have a positive impact on spin-offs and vice-versa for private funding. Two studies [7, 17] find a positive effect of public sector finding on the number of spin-offs. In contrast, one study finds a negative effect of private sector funding [17], while two more find no effect [4, 7].

Study 4 (SMS3 – university) discussed above finds evidence that commercial orientation of research (industry-funded research) has no effect on the number of spin-offs.

Study 7 (SMS3 – university) discussed above finds evidence that public funding increases the number of spin-offs, but private funding has no effect.

Study 17 (SMS2 – researcher) investigates multiple factors that may explain why some university researchers are more likely to create spin-off companies, using data on 1554 university researchers in Canada for the period 1997-2002. The outcome of interest is a binary indicator that takes the value of one whenever a new spin-off company is created to commercially exploit knowledge created by the university researchers. For explanatory factors, the study considers industry financial support (private funding) versus university-industry research partnership funds; whether the researcher is actively involved in intellectual property protection or consulting; the personal characteristics (experience, rank), teaching hours, research field and publication assets of researchers (total number of articles, book chapters and books published within 5 years); whether the research is novel or is linked to commercial opportunities; if there is a link between researchers and managers from private firms, government departments, or university communication departments; the size of the university and the laboratory. The study estimates a logit model. A mixture of personal characteristics (experience, gender, previous involvement in seeking to protect intellectual property and some others), university characteristics (university and research unit size) and specific specialisms are positively correlated with increased spin-offs. For our purposes, the most interesting results relate to funding. Increases in financial resources from private firms have a negative impact on university spin-offs (26% less likely), while receiving funding from public and university–industry partnership grants has a positive impact (31% more likely). These findings suggest that getting financial support from private firms might encourage researchers to transfer their knowledge directly to the supporting firms, rather than launching independent spin-offs.

The evidence is mixed on whether university patenting activity and eminence increases spin-offs. Two studies find positive effects of patent activity [6, 11] on the number of spin-offs, one no effect [7] and one negative effect [13]. Three studies [4, 5, 9] find that more eminent universities (measured by the number of graduate staff and quality of research) have more spin-offs. However, two studies [7, 14] find no effect.

Study 4 (SMS3 – university) discussed above finds evidence that more eminent universities have more start-ups.

Study 5 (SMS2 – firms) discussed above finds evidence that the quality of research has a positive effect on spin-offs.

Study 6 (SMS2 – university) discussed above finds evidence that patent regulations are positively correlated to spin-offs.

Study 7 (SMS3 – university) discussed above finds evidence that measures of university scientific productivity and previous patenting experience (both at the university and regional level) have no effect on spin-offs.

Study 9 (SMS3 – university) discussed above finds evidence that university eminence (based on a national ranking) positively impact spin-off quantity, but not quality.

Study 11 (SMS2 – university) discussed above finds evidence that the number of spin-offs is positively related to patenting activity.

Study 13 (SMS3 – university) discussed above suggests that university patenting activity is negatively related to spin-offs.

Study 14 (SMS2 – university) discussed above finds evidence that the quantity and quality of research staff have no impact on the number of spin-offs.

The size of a university may increase spin-offs. Two studies [10, 17], find that the size of the university measured by the number of faculty members seems to increase spin-offs (although only one of these is clear that the effect is more than proportionate).

Study 10 (SMS2 – university) discussed above finds evidence that large-sized universities are positively related to the number of spin-offs.

Study 17 (SMS2 – researcher) discussed above finds evidence that university characteristics (such as university and research unit size) are positively correlated with increased spin-offs.

Annexe: evidence reviewed

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