Institutional determinants of university spin-off quantity and quality: longitudinal, multilevel evidence from Italy, Norway and the UK

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Abstract

The creation of spin-off firms from universities are seen as an important mechanism for the commercialization of research, and hence the overall contribution from universities to technology development and economic growth. Governments and universities are seeking to develop framework conditions that are conductive to spin-off creation. The most prevalent of such initiatives are legislative changes at national level and the establishment of Technology Transfer Offices (TTO) at university level. The effectiveness of such initiatives is debated, but empirical evidence is limited. In this paper we analyze the full population of universities in Italy, Norway, and the UK; three countries adopting differing approaches to framework conditions, to test whether national and university level initiatives influence on the number of spin-offs created and the performance of these spin-offs. Building on institutional theory and using multi-level analysis, we find that changes in the institutional framework conditions at both national and university level are conductive to the creation of more spin-offs, but that the increase in quantity is at the expense of the quality of these firms. Hence, the effect of such top-down changes in framework conditions on the economic impact from universities seems to be more symbolic than substantive.

1. Introduction

The creation of new ventures to commercialize university research is potentially an important mechanism for technology diffusion that is seen to have significant economic impact at national and regional levels (Garnsey and Heffernan, 2005; Smith and Ho, 2006; Vincett, 2010; Wright et al., 2008). Governments have introduced many initiatives to promote spin-off creation, such as legislative changes and economic support for setting up support initiatives at university level, such as technology Transfer Offices (TTOs). However, the effects of such initiatives on spin-off creation are yet not well understood.

Although there has been an increase in the number of spin-offs created both in the US and Europe (Shane, 2004; Wright et al., 2007), there are concerns that the majority of these firms have limited growth and impact (Grimaldi et al., 2011). Especially in Europe, several studies have noted that the majority of university spin-offs remain small and appears to be lifestyle firms rather than high-growth ventures (Borlaug et al., 2009; Bolzani et al., 2014; Clarysse et al., 2007; Harrison and Leitch, 2009). Hence, it could be questioned: i) whether the framework conditions put at place at national and university level may have different impact on the quantity and quality of these firms, and ii) whether the observed growth in the number of university spin-offs results in a more symbolic, rather than substantive, increase in the economic impact from university technology transfer.

The commercialization of research, and spin-off creation in particular, is a rather new and unfamiliar activity at many academic institutions across Europe. Creating a successful spin-off firm requires different competencies compared to the traditional core academic missions of teaching and research (Ambos et al., 2008; Rasmussen et al., 2011). The effectiveness of top-down policies and legislative changes to promote commercialization have been debated (Goldfarb and Henrekson, 2002; Kenney and Patton, 2011); individual and social factors appear to have a much stronger impact on the propensity of academics to be involved in entrepreneurial activities than institutional arrangements such as TTOs (Clarysse et al., 2011). Therefore, we can hold that the creation and development of spin-off in a university context is a highly complex task involving many actors within and outside the university organization (O'Shea et al., 2007; Rasmussen and Borch, 2010; Rasmussen et al., 2014a). Hence, changes in the institutional framework, at both national and

university-level, may only have modest effects unless fully embraced at all levels within the academic organization (Fini and Lacetera, 2010).

Most research investigating the output of universities in terms of spin-off creation has measured the number of firms and paid limited attention to the quality of these firms (Lockett and Wright, 2005; Powers and McDougall, 2005; Van Looy et al., 2011). Similarly, there is a paucity of research that compares different countries (Clarysse et al., 2007). Hence, the evidence about the effect of changes in the institutional framework on spin-off creation is limited, and more research addressing this void is timely. In this study we pose the following research question: How do changes in the institutional framework at national and university level influence both the quantity and quality of spin-off from a university?

To explore this question we build on institutional theory proposing that changes in formal structures may result in symbolic rather than substantial modifications in operation efficiency (Dimaggio and Powell, 1983; Tolbert et al., 2011; Baldini et al., 2014 b). We rely on a unique panel dataset comprising the 2323 spin-offs created and the performance of these spin-offs from the full population of universities in Italy, Norway and the UK, between 2000 and 2012. Our findings reveal that changes in the institutional framework, such as the changes in the IPR legislation at national level and the establishment of a TTO at university level, have a positive effect on the number of spin-off created, while the average performance of these ventures decreases.

Our study makes several contributions to the literature on academic entrepreneurship and the commercialization of the university research. First, while several studies have looked at the link between institutional determinants and the number of spin-offs created from universities, this study teases out the effect of national and local initiatives in predicting the quality of the firms created. Second, most datasets of university spin-offs comprise a single university or single country, and, in the vast majority of the cases, rely on cross-sectional research designs. As this study compares the full population of universities across three different national contexts over a 13-year period, we extend understanding of the within- and between-country influences on the quantity and quality of university spin-offs. Third, we show that differences in the macro-institutional context regarding the ownership of IP from universities are significantly associated with the extent and nature of university spin-offs.

The paper proceeds as follows. In the next section we develop hypotheses related to how changes in university and national frameworks may influence the number of spin-offs created and the performance of these firms. The method section outlines our panel study of spin-off creation and performance in the full population of universities in Italy, Norway and the UK. Then the findings from our multi-level panel study are presented. Finally, conclusions and implications for research and practice are provided.

2. Theory and development of hypotheses

University spin-off creation is dependent on entrepreneurs who typically adapt their behavior and strategic model according to the opportunities and limitations of the formal and informal institutional framework they're exposed to (North, 1990). Institutional theory is particularly helpful in understanding entrepreneurship in organizational contexts, which are largely determined by culture, tradition, history, legal environment and economic incentives (Aldrich and Fiol, 1994; Bruton et al., 2010). The institutional context clearly influences university spin-off creation, as seen by the uneven and path dependent numbers of spin-offs created across universities (O'Shea et al., 2005). Moreover, it seems clear that university faculty complies with local group norms when it comes to involvement in spin-off creation (Bercovitz and Feldman, 2008; Louis et al., 1989; Rasmussen et al., 2014a).

The creation of a TTO may be a symbolic action to signal that the university sees spin-offs as a part of its strategy. As such, the number of spin-offs created may be expected to increase, as officers in TTOs seek to meet activity-based targets. However, the creation of quality university spin-offs is a highly complex process requiring access to entrepreneurial competencies to help the venture overcome the initial critical junctures (Rasmussen et al., 2011; Vohora et al., 2004). The creation of high-performing spin-offs appears to be more dependent on individual and group level characteristics, rather than on formal structures and policies (Kenney and Goe, 2004; Rasmussen et al., 2014a; Shane and Stuart, 2002; Lockett and Wright, 2005). TTOs need to have the capabilities to be able to make spin-offs investor ready and to have the social networks to identify and attract VC investors. Thus, there may be a mismatch between universities' intention to create quality spin-offs and the resources and capabilities they have to achieve this goal (Clarysse et al., 2005). Further, the opportunity recognition capacity and prior entrepreneurial experience of academics

have a much stronger influence on the propensity for quality new spin-off creation (Clarysse et al., 2011). To be effective, changes in framework conditions, such as TTO establishment, need to trigger the development of appropriate competencies and behavior at lower levels in the organization. For university spin-off creation this means that scientists and their surrounding environment must be both willing and capable of becoming engaged in pursuing potential high-growth spin-off firms. Without a full transformation of the university, its capabilities and its surrounding ecosystem, the establishment of a TTO may be only a symbolic act with limited effect on bringing new research to the market. A TTO may improve output targets such as creating more spin-offs, but the additional new ventures are not likely to become high-growth firms. Hence we propose the following:

Hypothesis 1: Universities with a TTO will generate (a) more spin-off companies but of (b) lower average quality than universities without a TTO.

At the macro policy level, governments have implemented legislative frameworks that are believed to be conducive to scientist entrepreneurship. The most well-known such example is the US Bayh-Dole Act 1980 which assigned the ownership of IPR to universities (Stevens, 2004; Grimaldi, et al., 2011). The subsequent rise in patenting and licensing at US universities led to the general perception that this legislative change was highly successful, although empirical evidence suggested other explanations (Mowery et al., 2001). This legislation has been emulated by the majority of European countries where IPR ownership has been assigned to universities, rather than being held by academics (the so-called professor's privilege). The rationale has been to increase the commercial output from university research but changes have been implemented at different rates and in different forms in different countries. In some cases, the changes have been introduced and then reversed, such as in Italy.

The introduction of a new legislation to support economic-growth generates attention from policy-makers, practitioners and the general public (see for example the so-called 2009 Obama stimulus package in the US). It can be expected therefore, that legislative changes aimed at increasing the commercialization of university-research may foster the creation of more spin-off firms. The rationale for this is that media, TTO managers, as well as practitioners will tend to emphasize the presence of

such a new framework, thus positively fostering entrepreneurial entries. However, changes in policy stance regarding the acceptability or not of the professor's privilege and hence the ownership of IP emanating from universities increase the level of environmental uncertainty, thus making successful entrepreneurship more difficult. VCs, for example, will be less willing to invest spin-off firms, which they already perceive as more difficult than other high-tech cases and universities will take time to build the requisite capabilities and networks (Wright et al. 2006). Accordingly, we put forward the following:

Hypothesis 2: Universities in a context with higher variance in national Intellectual Property Rights (IPR) legislation will generate (a) more spin-off companies but of (b) lower average quality, than universities in a context with lower variance.

Finally, government legislations and university-level support mechanisms will also interact in predicting academic entrepreneurship. Given the top-down nature of the governmental and university frameworks, we might expect a self-reinforcing effect being at place. The idea is consistent with the evidence provided by Fini et al. (2010), who show that the introduction of a new national legislative framework to support entrepreneurship and the creation of university TTOs complement each other in predicting academic entrepreneurship. Accordingly, we might expect that universities with a TTO in place, operating in countries with high variance in the IPR legislation, will tend to generate even more spin-offs if compared to others. In a similar fashion, we can argue that the negative effect of TTO presence of quality will be increased in the presence of a higher variance in IPR legislation. Universities indeed may be less likely to invest in or building-up TTO capabilities, or to have had the time to do so. Hence we propose the following hypothesis.

Hypothesis 3: Universities with a TTO and in a context with higher variance in national IPR legislation will generate (a) more spin-off companies but of (b) lower average quality, than universities in a context with lower variance.

3. Research design and data

3.1 The institutional landscape

To test our hypotheses, we used data from three European countries: Italy, Norway, and the United Kingdom, in which institutional changes to support the commercialization of university research, at both national and university levels, have been implemented following different pathways.

At national level, as a result of the catalytic effect of the Bayh-Dole Act in the US (Mowery et al., 2001) and to boost technology transfer activities from public research institutions, several EU countries revoked the so-called "professor's privilege", which granted Intellectual Property Rights (IPR) on employees' inventions not to the employer but to the employees themselves (Geuna and Rossi, 2011). The UK was the first to abolish it in 1977, followed by France (1982), Spain (1986), the Netherlands (1995), Denmark (2000), Germany (2002) and Norway (2003). Italy, on the contrary, introduced the "professor's privilege" late in 2001, abandoning it in 2005 (Baldini et al. 2014 a).

In a similar fashion, UK universities have been proactive in introducing internal policies to foster technology transfer activities by academics; i.e., by year 2000 more than the 80% of UK universities had a TTO (UNICO/NUBS, 2002; Locket et al., 2014). The Norwegian universities, instead, established their TTOs later, between 2003 and 2005 (Borlaug et al., 2009); whereas the Italian ones have been the least proactive, with more than 40% of them without a TTO by the end of 2005 (Baldini et al., 2014 b).

This evidence suggests that, at both country and university level, the UK has been acting in establishing formal initiatives to enable technology transfer. Norway, with something of a lag, has put in place similar conditions, while Italy has lagged significantly behind.

3.2 The sample

To properly account for cross-national differences, we pooled data from different national and EU sources.

As to country-level information, data on gross domestic product and unemployment rates have been retrieved using the World Bank Database (http://data.worldbank.org). Data on the number of days required to start a business

was obtained from Doing Business project of the World Bank (http://www.doingbusiness.org/). Data on investment freedom was from the Index of Economic Freedom provided annually by the Heritage Foundation (http://www.heritage.org/index/download). Changes in the national IPR regimes have been coded according to the assessment provided by Baldini et al. (2014 a).

University-level data has been collected using a two-pronged strategy. First, through the EUMIDA database, we extracted harmonized, EU-level, time-invariant information on: universities' localization, legal status, year of establishment, educational fields, presence of a university hospital, and whether the university emphasizes Science Technology Engineering and Mathematics (STEM). The EUMIDA database stores information on 2,500 higher education institutions from 29 EU countries. Data refers to year 2008 (for details see, European Commission 2010).

Secondly, we relied on national sources, collecting time-variant information on universities' size (i.e., number of faculty members, number of PhD students), operational characteristics (i.e., number and size of research grants awarded from public institutions, number and size of grants and contracts secured from private organizations) and intellectual eminence (i.e., national university quality rankings). For the UK, data on size and operations have been retrieved through the Higher Education Information Database for Institutions (HEIDI) (https://heidi.hesa.ac.uk/Home.aspx). Data on universities' intellectual eminence has been assessed using the UK University League Tables and Rankings from the Complete University Guide (http://www.thecompleteuniversityguide.co.uk/league-tables/rankings). For Norway comparable data on size and operations were obtained from the Database for Statistics on Higher Education (DBH - http://dbh.nsd.uib.no/), Science and Technology Indicators for Norway (INDIKATORRAPPORTEN) and on national position from the CWTS Leiden Ranking 2013, respectively. For Italy, we used the MIUR websites (MIUR 2013), as well as the overall academic rating score of Italian universities published in the "Grande Guida dell'Università" (Repubblica 2013).

Finally, firm-level data have been retrieved through both the universities' TTO and the national Companies' Houses. For the UK, data on firms were mainly retrieved from the Spinouts UK Survey (http://www.spinoutsuk.co.uk/), which includes all spinout companies from UK universities and institutions since 2000. This data was further complemented and corroborated by data from Fame

(https://fame.bvdinfo.com) and Zephyr (https://zephyr.bvdinfo.com). For Norway, firm-level data originates from a database maintained by the Research Council of Norway's FORNY-program which is designed to support universities in commercializing research results (Borlaug et al., 2009). This data has been complemented with information from the companies' annual reports accessed through the Norwegian Register of Company Accounts (http://www.brreg.no/english/) as well as TTOs' databases, media archives, web-pages and other secondary information. For Italy, the list of firms has been compiled by contacting the universities' TTOs every two years since 2003, the last time being 2013. Each firm has been looked up on Infocamere Telemaco (https://telemaco.infocamere.it/), the database of the Italian Companies House, retrieving information on the operational characteristics as well as on the capital structure.

The final dataset comprises 185 universities (68 from Italy (IT), 4 from Norway (NO) and 113 from the UK) and their 2323 spin-offs (878 from IT, 120 from NO, and 1325 from UK) from the three European countries. The observation period is from 2000 to 2012.

3.3 Dependent variables

University spin-offs Quality and Quantity are the two dependent variables. We index quantity as a count of the number of university spin-offs from a given university in a given year. Following previous work (e.g. Lockett and Wright, 2005), we operationalize quality as a count of the number of university spin-offs from a given university in a given year, which have received the first round of VC-financing in that year. Being able to attract VC provides a measure of external validation of quality in terms of expected returns.

3.4 Predictor variables

Establishment of the University TTO. To measure the effect of TTO presence on university spin-offs quality and quantity, we specified a dummy variable that switches from 0 to 1 the year in which the TTO is established. If the TTO was established before 2000, the variable takes the value of 1 throughout the whole observation period.

IPR Institutional Variance. To account for the effect of institutional variance in IPR-related-matters, we divided the number of changes in country's IPR legislation by the number of years included in the observation period (i.e. 13). This variable ranges from 0 (UK) to 0.15 (Italy). We also came up with other possible measures of the variance/turbulence in the institutional environment in a country, as discussed in the robustness checks section.

3.5 Control variables: Country-Level

Investment Freedom. Because we expect that spin-off quality would be positively influenced by fewer constraints on the flow of investment capital, we include the economic freedom index by the Heritage Foundation, as a measure of the level of freedom for individuals and firms to move their resources into/out-of specific activities in a given country in a given year. This index may range from 0 to 100; and in our sample countries is bounded between 50 and 90.

Ease of Doing Business. Higher-levels of bureaucracy may hinder entrepreneurial behaviors, especially the intention and likelihood of entry. To account for this aspect in the spin-off quantity model, we used data from the World Bank, examining the number of days required to start a business in a given country in a given year. In the sample, this variable ranges from 6 to 23.

Gross Domestic Product per capita (GDP per capita). The environmental conditions also influence the structure of opportunities to be exploited by individuals. The higher the gross domestic product, the more the resources flowing into innovation and research, the higher the likelihood that entrepreneurship would occur. To account for this, we included in our models the gross domestic product of a given country in a given year, discounted by the yearly consumer price index. The variable was logarithm transformed and its value in the sample ranges from 10.4 to 11.1.

Unemployment Rate. Similarly, countries with higher unemployment rates, may originate less high-tech entrepreneurship compared to those with lower rates. To properly account for this, we examined the unemployment rate of a given country in a given year. The rate in our sample is bounded between 2.5 and 10.8.

3.6 Control variables: University-Level

Foundation Year. Under the assumption that the older the university, the higher the prestige of the institution, the higher its impact, we control for the university's year of establishment.

Size. University size may also be a predictor of university spin-off activity. The higher the number of faculty members and support staff, the higher the likelihood that some research may be effectively transferred to the market. To account for this we control for the number of employees of a given university in a given year.

Sponsored research expenditure. Because the knowledge exploited by spin-offs is generated by university research, we may expect that that the amount of research money secured from for-profit institutions by a given university in a given year will be likely related to the spin-off quantity and quality. The variable is operationalized in monetary terms and is discounted for the yearly consumer price index.

Prior knowledge in technology-transfer activities. University TTO expertise in supporting spin-offs may take some time to develop. Some universities have been involved in technology transfer activities even before 2000. In order to account for the knowledge that may have originated in that specific regard, we control for the cumulative number of university spin-offs established before 2000 by a given university.

Cumulative entry. The number of firms from a given university receiving VC funding in a given year can be positively correlated with the total number of spin-offs emerging from that university until the year of observation. We therefore control for the cumulative number of spin-off from a university up to the focal year in the quality model.

Intellectual eminence. We also assume that the universities' intellectual eminence may be related to their ability to foster entrepreneurial behavior by academics. We relied on national rankings to categories each university in either the top 25%, 25-50%, 50-75% and worst 25%. The variable is country-specific and time-variant.

Educational fields. We account for the comprehensiveness of the educational offering by the universities under scrutiny. Relying on the information stored in EUMIDA, we assessed whether each university had education programs in each of the following fields: General programs; Education; Humanities and Arts; Social Sciences, Business and Law; Sciences; Engineering, Manufacturing and Construction; Agriculture; Health and welfare; Services. The nine variables are time-invariant and can take the value of either 0 or 1.

Industrial variance. We finally controlled for the variance in the industrial sectors of each university in a given year. This is because firm performance could be influenced by the number of firms that are similar to them emerging from the same university in the same year. The higher the industrial variance, the lower the critical mass of similar others, the less the competition and more resources a firm would get, which would result in better performance.

4. Econometric models

As our data features a hierarchical structure at multiple levels, we applied a multilevel modeling approach to model and test the proposed set of hypotheses (Bliese et al. 2007). Specifically, our dataset is a time-series cross-sectional data at university level, which is clustered within three countries, over 13 years. Therefore university-level data are likely to be correlated over-time; moreover, universities from the same country may be more similar than those selected randomly. Therefore, ignoring the multilevel structure can result in violating the assumption of data independence in traditional multiple regressions, which gives rise to unreliable estimates. Indeed, multilevel modeling enables us to account for interdependence by capturing residual at different levels.

Moreover, in the current study, we are not only interested in the effect of university-level predictors, but we also aim to assess to what extent country-level institutional dimensions impact the quantity and quality of university spinouts. Multilevel modeling provides ways to evaluate the impact of factors from different levels simultaneously, and makes the test of cross-level interaction effects possible.

Finally, as both dependent variables in the analyses are measured by count data with overdispersion, we chose multilevel negative binomial regressions over

multilevel poisson modeling, nesting university-level data (level 1) into country-level ones (level 2).

5. Results

Main models

Table 1 shows descriptive statistics and Table 2 shows the correlation matrix for all variables in our models.

Insert Tables 1 and 2 about here

We present the estimation results on the *quantity* of university spinouts in Table 3. Model 1 in Table 3 shows the baseline model that includes university-level and country-level control variables only. The main effects of TTO establishment and institutional variance were estimated in Model 2 in Table 3. The cross-level interaction effect was tested in Model 3 with the introduction of the cross-level interaction term.

As we can see from Model 2, the establishment of a university TTO has a significant positive effect on the number of spin-offs emerging from the university (0.244, $p<0.01$). The level of institutional variance in IPR regime at country level shows a significant positive influence on the entry of spinouts from university (7.789, $p<0.001$). The interaction effect of university TTO and country-level institutional variance shown in Model 3 is positive and significant (4.26, $p<0.01$). Therefore Hypotheses 1a, 2a and 3a are supported.

Insert Table 3 about here

The estimation results on the *quality* of university spinouts are shown in Table 4. As before, Model 4 in Table 4 shows the baseline model with control variables only.

Model 5 shows the main effects of TTO establishment and IPR institutional variance. The cross-level interaction effect is displayed in Model 6.

Regression results of Model 5 in Table 4 show that the establishment of a university TTO has a negative effect on the quality of university spinouts, although the coefficient is only marginally significant (-0.344, $p<0.1$). Country-level institutional variance in IPR regime has a significant negative influence on the quality of university spinouts (-7.25, $p<0.01$). The interaction effect of the two variables is also negative and statistically significant (-7.28, $p<0.05$) as shown in Model 6. The above results provide support for Hypotheses 1b, 2b and 3b.

Insert Table 4 about here

Robustness checks

To check for the stability and replicability of our results, we also run the selected econometric specifications using two alternative operationalizations of the *IPR Institutional Variance* construct. We obtained the first alternative measure by dividing the number of years in which the professor's privilege was in place during the observation period, by the total years included in the observation period (13). This index ranges from 0 (UK) to 0.38 (Italy). The second alternative measure was the count of absolute number of changes in the IPR legislation, which is the number of switches between enforcement of 'professor's privilege' and 'university's privilege' in a country over the 13 years observation time. The value of this variable changes from 0 (UK) to 2 (Italy).

We adopted the same model specifications for both spin-off quantity and quality in the robustness checks as the ones used in the previous test respectively. The results remain unchanged. We present the results of the robustness checks in Appendixes A and B.

6. Conclusions and implications

Our study, using a unique panel dataset and multi-level analysis comprising the populations of university spin-offs in three European countries, shows that changes in the institutional framework have a positive effect on the number of spin-offs created, but a negative effect on the quality of these ventures, as measured by their ability to attract VC. These findings indicate that the implementation of new institutional frameworks to increase spin-off creation has an effect, but this effect appears to be more symbolic than substantive.

Hence, when governments and universities introduce changes in framework conditions to increase spin-off creation, the response within the university organization is to maximize the number of firms created without being able to improve the potential economic impact of these firms. University scientists appear to comply with the new institutional norms of creating more spin-offs, without being more capable of doing so.

Our findings have a number of implications for practice and policy. It has been debated whether the most efficient policies for commercialization of research are bottom-up or top-down (Goldfarb and Henrekson, 2002; Rasmussen, 2008). Top-down policies face the risk of being met by strategic responses at the lower levels (Oliver, 1991), thus enacting mimetic behaviors (Baldini et al., 2014b). Top-down initiatives may lead to symbolic conformance in terms of an increase in the number of spin-offs. However, the creation of quality spin-offs is a complex and resource demanding process that requires more substantial changes at all levels within the universities. Hence, legislative changes and university level initiatives, such as the establishment of TTOs, need to be complemented with bottom-up initiatives.

Our results therefore provide a general indication across countries that it is insufficient to establish a TTO or to have a long-established TTO for the development of quality spin-offs. Rather it would seem to be important that universities develop capabilities within their entire organization and surrounding ecosystem that can provide the necessary support to make spin-offs investor ready for VC and other external investment. Earlier qualitative evidence from across European universities (Clarysse et al., 2005) has identified capability deficiencies in TTOs in this respect, and our evidence would seem to suggest that these within and between country differences persist. It would also seem to be important that universities and TTOs in

different countries develop the social capital to be able to attract VC and other external investment (Rasmussen et al., 2014b), especially as VC investors typically view spin-offs as being more challenging propositions than regular high tech start-ups (Wright et al., 2006). Our analysis also suggests a need for policy towards the commercialization of university research to be connected closely to the development of policies towards entrepreneurship and the funding of entrepreneurial ventures.

Our paper has limitations that open up avenues for further research. First, while we selected countries with differences in their institutional approaches to academic entrepreneurship, further research is needed to explore whether our results hold for other countries or whether there are additional differences. Second, we measured quality by the ability of spin-offs to attract VC funding. Data limitations restricted our ability to measure access to other external funding notably business angel funding which may be especially important for early stage spin-off ventures. Further research is needed to explore the role of access to different forms of external investment funds. Additionally, we do not analyze subsequent accounting, financial and economic performance of spin-offs following VC investment. Further research is needed to explore this aspect, although cross-country data limitations may constrain this approach, especially for smaller spin-offs that have yet to generate revenues. Third, as we have indicated, policies towards the commercialization of university IP have varied over time within and across countries, which have implications for university strategies towards the extent and types of spin-offs (Lockett et al., 2014). While our panel data analysis helps to pick up the quantitative effects of these variations, complementary fine-grained qualitative analysis is required concerning the adaptation of the spin-off processes adopted by universities in different countries. For example, TTOs may be centralized or decentralized which may have implications for the locus of capabilities to support spin-offs and the social capital of technology transfer officers to access external funding (Huyghe et al., 2014). Fourth, although we measured differences in investment freedom across countries, data limitations restricted our ability to account for cross-country and within-country differences in access to external finance. Countries differ in the extent of development of VC markets as well as business angel markets, but the proliferation of new sources of venture funding such as crowd-funding and accelerators potentially introduces additional within and between country variations. Subsequent efforts to encompass these differences will be become more important over time. Fifth the private or public

legal status of a university may be important. Private universities may be less constrained in investing resources into technology transfer activities compared to public ones. However, we were unable to explore this aspect of the influence on spin-off activity as in our three countries the number of private universities is too small. Future studies might examine this issue in contexts with a higher incidence of private universities, such as the US. Finally, we have focused on within- and across-country differences in university spin-offs but TTOs are also involved to a greater or lesser extend or degree of success in other dimensions of commercialization activity. Given the limited qualitative (Wright et al., 2008) and quantitative analyses (e.g. Chapple et al., 2005) of these multiple outputs, additional cross-country examination is warranted.

In sum, the creation of spin-off firms from universities are increasingly seen internationally as an important mechanism for the commercialization of research, and hence form a central element in the overall contribution of universities to technology development and economic growth. Governments and universities are developing framework conditions that are conductive to spin-offs but as yet there is limited systematic cross-country comparative analysis of the influences on the extent and quality of spin-offs created. Our study adds to the so far limited cross-country analyses of these influences and points the way to further cross-country analyses and policy developments.

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Exhibits

Table 1 Descriptive Statistics

Variable	Observation	Mean	Std. Dev.	Min	Max
Spinout quantity	2405	0.97	2.11	0	31
Spinout quality	2405	0.15	0.59	0	8
TTO establishment	2405	0.72	0.45	0	1
IPR Institutional variance	2405	0.16	0.20	0	0.38
Cumulative entry	2405	6.79	14.44	0	197
Prior knowledge in technology-transfer activities	2405	5.29	16.47	0	115
Foundation year	2405	1838	207	1088	2004
Sponsored research expenditure	2405	6.60	2.26	0	10.48
Size	2405	7.26	1.13	1.39	9.28
Intellectual eminence: Rank top 25%	2405	0.25	0.43	0	1
Intellectual eminence: Rank 50-75%	2405	0.26	0.44	0	1
Intellectual eminence: Rank 25-50%	2405	0.24	0.43	0	1
Education Field; General	2405	1.01	0.07	1	2
Education Field; Education	2405	1.72	0.45	1	2
Education Field; Humanities and Arts	2405	1.90	0.30	1	2
Education Field; Social Sciences, Business and Law	2405	1.97	0.16	1	2
Education Field; Sciences	2405	1.91	0.29	1	2
Education Field; Engineering, Manufacturing and Construction	2405	1.85	0.36	1	2
Education Field; Agriculture	2405	1.48	0.50	1	2
Education Field; Health and Welfare	2405	1.89	0.31	1	2
Education Field; Services	2405	1.64	0.48	1	2
Industrial variance	2405	2.03	3.14	0	24.5
GDP per capita	2405	10.52	0.10	10.39	11.10
Easiness of doing business	2405	13.14	4.10	6	23
Unemployment rate	2405	6.8	1.82	2.5	10.8
Investment freedom	2405	77.62	10.01	50	90

Table 2 Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Spinout quantity	1.00												
2 Spinout quality	0.46	1.00											
3 TTO establishment	0.14	0.08	1.00										
4 IPR Institutional uncertainty	0.02	-0.13	-0.36	1.00									
5 Cumulative entry	0.65	0.53	0.17	-0.03	1.00								
6 Prior knowledge in tech-transfer	0.64	0.57	0.12	-0.18	0.73	1.00							
7 Foundation year	-0.31	-0.17	-0.05	-0.19	-0.32	-0.34	1.00						
8 Sponsored research expenditure	0.40	0.27	0.03	0.21	0.44	0.35	-0.30	1.00					
9 Size	0.31	0.29	0.32	-0.53	0.37	0.36	-0.25	0.41	1.00				
10 Rank top 25%	0.30	0.24	-0.07	-0.02	0.34	0.31	-0.11	0.28	0.15	1.00			
11 Rank 50-75%	0.03	0.01	-0.02	0.00	0.03	0.02	-0.07	0.18	0.13	-0.34	1.00		
12 Rank 25-50%	-0.15	-0.13	0.09	0.01	-0.17	-0.16	0.05	-0.18	-0.08	-0.33	-0.33	1.00	
13 Education Field; General	0.00	0.05	-0.02	0.02	0.01	-0.02	0.05	0.04	0.02	-0.04	-0.04	-0.04	1.00
14 Education Field; Education	-0.02	0.00	0.13	-0.26	-0.03	-0.03	-0.06	-0.11	0.27	-0.23	0.06	0.08	0.05
15 Education Field; Humanities and Arts	-0.04	-0.05	0.11	-0.31	-0.05	-0.01	-0.19	0.02	0.43	-0.08	0.05	0.06	0.02
16 Education Field; Social Sciences	-0.05	0.03	0.06	-0.22	-0.07	0.04	-0.08	-0.01	0.16	-0.16	0.05	0.05	0.01
17 Education Field; Sciences	0.09	0.08	0.24	-0.33	0.10	0.10	-0.13	0.18	0.52	-0.10	0.09	0.02	0.02
18 Education Field; Engineering	0.15	0.09	0.27	-0.09	0.16	0.12	-0.13	0.25	0.37	-0.07	0.04	0.06	-0.17
19 Education Field; Agriculture	0.10	0.07	0.13	-0.09	0.11	0.15	-0.17	0.08	0.23	-0.16	0.04	-0.03	0.08
20 Education Field; Health	0.06	0.07	0.14	-0.12	0.06	0.08	-0.15	0.12	0.31	-0.12	0.03	0.04	0.03
21 Education Field; Services	-0.16	-0.20	-0.01	0.25	-0.21	-0.22	-0.07	-0.13	-0.13	-0.39	-0.01	0.19	0.06
22 Industrial variance	0.33	0.12	0.15	0.22	0.31	0.15	-0.25	0.43	0.16	0.13	0.12	-0.08	0.00
23 GDP per capita	0.06	0.24	0.28	-0.51	0.14	0.07	0.13	0.00	0.37	0.01	0.00	-0.01	0.28
24 Easiness of doing business	-0.08	-0.05	-0.36	0.15	-0.20	-0.02	-0.03	-0.12	-0.16	0.00	0.00	0.01	-0.03
25 Unemployment rate	-0.08	-0.16	-0.32	0.63	0.01	-0.10	-0.14	0.06	-0.38	-0.01	0.00	0.01	-0.13
26 Investment freedom	-0.08	0.04	0.23	-0.55	0.13	0.11	0.09	-0.15	0.28	0.01	0.00	-0.01	-0.17

	14	15	16	17	18	19	20	21	22	23	24	25	26
14 Education Field; Education	1.00												
15 Education Field; Humanities and Arts	0.34	1.00											
16 Education Field; Social Sciences	0.27	0.38	1.00										
17 Education Field; Sciences	0.18	0.32	0.41	1.00									
18 Education Field; Engineering	0.14	0.01	0.02	0.28	1.00								
19 Education Field; Agriculture	0.17	0.15	0.16	0.23	0.17	1.00							
20 Education Field; Health	0.29	0.28	0.37	0.49	0.19	0.20	1.00						
21 Education Field; Services	0.20	0.15	0.15	0.11	0.09	0.21	0.28	1.00					
22 Industrial variance	-0.10	-0.01	-0.04	0.07	0.13	0.04	0.04	-0.01	1.00				
23 GDP per capita	0.19	0.12	0.13	0.21	0.02	0.01	0.10	-0.21	-0.03	1.00			
24 Easiness of doing business	-0.05	-0.04	-0.03	-0.05	-0.01	-0.01	-0.02	0.05	-0.26	-0.27	1.00		
25 Unemployment rate	-0.19	-0.18	-0.14	-0.23	-0.05	-0.04	-0.09	0.20	0.10	-0.68	0.22	1.00	
26 Investment freedom	0.11	0.19	0.11	0.16	0.06	0.07	0.05	-0.10	-0.06	0.26	-0.19	0.01	1.00

Number of observation: 2405

Table 3 Results of Multilevel Negative Binomial Regression: Spin-off Quantity

	Model 1	Model 2	Model 3
TTO establishment		0.244**	-0.082
		(0.084)	(0.120)
IPR Institutional variance		7.789***	4.552***
		(0.911)	(1.269)
TTO X Institutional variance			4.260***
			(1.144)
Prior knowledge in technology-transfer activities	0.016***	0.017***	0.019***
	(0.001)	(0.001)	(0.002)
Foundation year	0.000	0.000	0.000+
	(0.000)	(0.000)	(0.000)
Sponsored research expenditure	0.385***	0.309***	0.286***
	(0.037)	(0.034)	(0.035)
Size	0.124+	0.248***	0.247***
	(0.071)	(0.068)	(0.068)
Intellectual eminence: Rank top 25%	0.833***	0.877***	0.879***
	(0.118)	(0.118)	(0.118)
Intellectual eminence: Rank 25-50%	0.648***	0.699***	0.715***
	(0.110)	(0.110)	(0.111)
Intellectual eminence: Rank 50-75%	0.263*	0.255*	0.270*
	(0.118)	(0.118)	(0.118)
Education Field; General	1.076*	1.098**	1.103**
	(0.421)	(0.410)	(0.409)
Education Field; Education	0.024	0.021	-0.038
	(0.074)	(0.073)	(0.075)
Education Field; Humanities and Arts	-0.054	0.022	0.050
	(0.135)	(0.133)	(0.134)
Education Field; Social Sciences, Business and Law	-1.426***	-1.100***	-1.089***
	(0.285)	(0.281)	(0.280)
Education Field; Sciences	0.899***	0.827***	0.717**
	(0.224)	(0.219)	(0.219)
Education Field; Engineering, Manufacturing and Construction	0.678***	0.649***	0.704***
	(0.159)	(0.160)	(0.160)
Education Field; Agriculture	0.065	0.069	0.066
	(0.066)	(0.066)	(0.066)
Education Field; Health and Welfare	0.229	0.139	0.269
	(0.176)	(0.177)	(0.181)
Education Field; Services	0.089	-0.057	-0.027
	(0.087)	(0.086)	(0.086)
GDP per capita	0.155	-0.510	-0.328
	(0.703)	(0.455)	(0.470)
Easiness of doing business	-0.019	-0.022*	-0.014
	(0.017)	(0.010)	(0.011)
Unemployment rate	-0.038	-0.155***	-0.146***
	(0.056)	(0.032)	(0.033)
Constant	-7.799	-1.725	-3.592
	(7.712)	(4.827)	(4.999)
Lnalpha	-0.732***	-0.753***	-0.775***
	(0.109)	(0.110)	(0.111)
Variance of intercept	0.140**	0.014	0.018
	(0.054)	(0.012)	(0.013)
Observations	2,405	2,405	2,405
Number of groups	39	39	39
Log likelihood	-2426	-2397	-2390
Chi2	1286	1353	1374

Standard error is in parentheses. p < 0.001***; p<0.01**; p<0.05*; p<0.1+.
Observations are grouped per country-year.

Table 4 Results of Multilevel Negative Binomial Regression: Spin-off Quality

	Model 4	Model 5	Model 6
TTO establishment		-0.344+	-0.084
		(0.197)	(0.230)
IPR Institutional variance		-7.250**	-1.894
		(2.303)	(3.175)
TTO X Institutional variance			-7.280*
			(3.167)
Cumulative entry	0.012***	0.012***	0.011***
	(0.003)	(0.003)	(0.003)
Industrial variance	0.117***	0.125***	0.130***
	(0.032)	(0.031)	(0.030)
Foundation year	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
Size	1.309***	0.961***	0.917***
	(0.195)	(0.230)	(0.225)
Sponsored research expenditure	0.138	0.240*	0.283**
	(0.088)	(0.102)	(0.102)
Intellectual eminence: Rank top 25%	1.077**	1.010*	1.015*
	(0.415)	(0.421)	(0.417)
Intellectual eminence: Rank 25-50%	1.009*	0.934*	0.910*
	(0.397)	(0.401)	(0.399)
Intellectual eminence: Rank 50-75%	0.041	0.061	0.020
	(0.458)	(0.457)	(0.457)
Education Field; General	3.610***	3.327**	3.114**
	(1.028)	(1.017)	(1.010)
Education Field; Education	-0.024	-0.108	-0.029
	(0.159)	(0.164)	(0.165)
Education Field; Humanities and Arts	-0.577*	-0.617*	-0.564*
	(0.275)	(0.270)	(0.268)
Education Field; Social Sciences, Business and Law	1.279	0.393	0.174
	(1.003)	(1.055)	(1.057)
Education Field; Sciences	0.955	0.885	0.976
	(1.227)	(1.262)	(1.257)
Education Field; Engineering, Manufacturing and Construction	1.586*	1.698*	1.541*
	(0.772)	(0.769)	(0.767)
Education Field; Agriculture	0.028	0.005	0.017
	(0.155)	(0.152)	(0.151)
Education Field; Health and Welfare	-0.836+	-0.508	-0.621
	(0.478)	(0.480)	(0.481)
Education Field; Services	-0.187	0.147	0.127
	(0.169)	(0.190)	(0.188)
GDP per capita	2.424***	3.006***	3.217***
	(0.625)	(0.618)	(0.602)
Investment freedom	-0.004	-0.012+	-0.011
	(0.008)	(0.007)	(0.007)
Constant	-48.44***	-49.40***	-51.21***
	(6.960)	(6.766)	(6.601)
Lnalpha	-0.896*	-1.130**	-1.221**
	(0.365)	(0.425)	(0.451)
Variance of intercept	0.042	0.012	0.008
	(0.047)	(0.032)	(0.029)
Observations	2,405	2,405	2,405
Number of groups	39	39	39
Log likelihood	-666.1	-660.4	-657.9
Chi2	482.8	528.0	544.8

Standard error is in parentheses. p < 0.001***; p<0.01**; p<0.05*; p<0.1+.
Observations are grouped per country-year.

Appendix A-1 Results of Multilevel Negative Binomial Regression: Spin-off Quantity

	Model 1a	Model 2a	Model 3a
TTO establishment		0.248**	-0.073
		(0.084)	(0.120)
IPR Institutional variance [a]		3.067***	1.810***
		(0.355)	(0.499)
TTO X Institutional variance			1.659***
			(0.457)
Prior knowledge in technology-transfer activities	0.016***	0.017***	0.019***
	(0.001)	(0.001)	(0.002)
Foundation year	0.000	0.000	0.000+
	(0.000)	(0.000)	(0.000)
Sponsored research expenditure	0.385***	0.308***	0.286***
	(0.037)	(0.034)	(0.035)
Size	0.124+	0.246***	0.246***
	(0.071)	(0.068)	(0.068)
Intellectual eminence: Rank top 25%	0.833***	0.879***	0.880***
	(0.118)	(0.118)	(0.118)
Intellectual eminence: Rank 25-50%	0.648***	0.699***	0.715***
	(0.110)	(0.110)	(0.110)
Intellectual eminence: Rank 50-75%	0.263*	0.253*	0.267*
	(0.118)	(0.118)	(0.118)
Education Field; General	1.076*	1.054**	1.075**
	(0.421)	(0.409)	(0.409)
Education Field; Education	0.024	0.018	-0.039
	(0.074)	(0.073)	(0.075)
Education Field; Humanities and Arts	-0.054	0.034	0.059
	(0.135)	(0.133)	(0.134)
Education Field; Social Sciences, Business and Law	-1.426***	-1.108***	-1.096***
	(0.285)	(0.281)	(0.279)
Education Field; Sciences	0.899***	0.826***	0.720**
	(0.224)	(0.218)	(0.219)
Education Field; Engineering, Manufacturing and Construction	0.678***	0.651***	0.704***
	(0.159)	(0.160)	(0.160)
Education Field; Agriculture	0.065	0.072	0.069
	(0.066)	(0.066)	(0.066)
Education Field; Health and Welfare	0.229	0.137	0.264
	(0.176)	(0.177)	(0.181)
Education Field; Services	0.089	-0.053	-0.025
	(0.087)	(0.086)	(0.086)
GDP per capita	0.155	-0.684	-0.538
	(0.703)	(0.457)	(0.471)
Easiness of doing business	-0.019	-0.022*	-0.015
	(0.017)	(0.010)	(0.011)
Unemployment rate	-0.038	-0.155***	-0.147***
	(0.056)	(0.032)	(0.033)
Constant	-7.799	0.169	-1.342
	(7.712)	(4.837)	(5.001)
Lnalpha	-0.732***	-0.756***	-0.777***
	(0.109)	(0.110)	(0.111)
Variance of intercept	0.140**	0.013	0.018
	(0.054)	(0.011)	(0.013)
Observations	2,405	2,405	2,405
Number of groups	39	39	39
Log likelihood	-2426	-2396	-2390
Chi2	1286***	1357***	1377***

Standard error is in parentheses. p < 0.001***; p<0.01**; p<0.05*; p<0.1+. Observations are grouped per country-year. a: measured by the ratio between number of years in which professor has privilege and 13-year observation time.

Appendix A-2 Results of Multilevel Negative Binomial Regression: Spin-off Quantity

	Model 1b	Model 2b	Model 3b
TTO establishment		0.244**	-0.082
		(0.084)	(0.120)
IPR Institutional variance [a]		0.600***	0.351***
		(0.070)	(0.098)
TTO X Institutional variance			0.328***
			(0.088)
Prior knowledge in technology-transfer activities	0.016***	0.017***	0.019***
	(0.001)	(0.001)	(0.002)
Foundation year	0.000	0.000	0.000+
	(0.000)	(0.000)	(0.000)
Sponsored research expenditure	0.385***	0.309***	0.286***
	(0.037)	(0.034)	(0.035)
Size	0.124+	0.248***	0.247***
	(0.071)	(0.068)	(0.068)
Intellectual eminence: Rank top 25%	0.833***	0.877***	0.879***
	(0.118)	(0.118)	(0.118)
Intellectual eminence: Rank 25-50%	0.648***	0.699***	0.715***
	(0.110)	(0.110)	(0.111)
Intellectual eminence: Rank 50-75%	0.263*	0.255*	0.270*
	(0.118)	(0.118)	(0.118)
Education Field; General	1.076*	1.098**	1.103**
	(0.421)	(0.410)	(0.409)
Education Field; Education	0.024	0.021	-0.038
	(0.074)	(0.073)	(0.075)
Education Field; Humanities and Arts	-0.054	0.022	0.050
	(0.135)	(0.133)	(0.134)
Education Field; Social Sciences, Business and Law	-1.426***	-1.100***	-1.089***
	(0.285)	(0.281)	(0.280)
Education Field; Sciences	0.899***	0.827***	0.717**
	(0.224)	(0.219)	(0.219)
Education Field; Engineering, Manufacturing and Construction	0.678***	0.649***	0.704***
	(0.159)	(0.160)	(0.160)
Education Field; Agriculture	0.065	0.069	0.066
	(0.066)	(0.066)	(0.066)
Education Field; Health and Welfare	0.229	0.139	0.269
	(0.176)	(0.177)	(0.181)
Education Field; Services	0.089	-0.057	-0.027
	(0.087)	(0.086)	(0.086)
GDP per capita	0.155	-0.510	-0.328
	(0.703)	(0.455)	(0.470)
Easiness of doing business	-0.019	-0.022*	-0.014
	(0.017)	(0.010)	(0.011)
Unemployment rate	-0.038	-0.155***	-0.146***
	(0.056)	(0.032)	(0.033)
Constant	-7.799	-1.725	-3.592
	(7.712)	(4.827)	(4.999)
Lnalpha	-0.732***	-0.753***	-0.775***
	(0.109)	(0.110)	(0.111)
Variance of intercept	0.140**	0.014	0.018
	(0.054)	(0.012)	(0.013)
Observations	2,405	2,405	
Number of groups	39	39	39
Log likelihood	-2426	-2397	-2390
Chi2	1286***	1353***	1374***

Standard error is in parentheses. p < 0.001***; p<0.01**; p<0.05*; p<0.1+. Observations are grouped per country-year. a: measured by absolute number of changes in IPR institution in a country.

Appendix B-1 Results of Multilevel Negative Binomial Regression: Spin-off Quality

	Model 4a	Model 5a	Model 6a
TTO establishment		-0.350+	-0.070
		(0.197)	(0.232)
IPR Institutional variance [a]		-2.838**	-0.663
		(0.895)	(1.238)
TTO X Institutional variance			-2.959*
			(1.232)
Cumulative entry	0.012***	0.012***	0.011***
	(0.003)	(0.003)	(0.003)
Industrial variance	0.117***	0.125***	0.130***
	(0.032)	(0.031)	(0.030)
Foundation year	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
Size	1.309***	0.971***	0.922***
	(0.195)	(0.227)	(0.223)
Sponsored research expenditure	0.138	0.236*	0.281**
	(0.088)	(0.101)	(0.101)
Intellectual eminence: Rank top 25%	1.077**	1.010*	1.014*
	(0.415)	(0.420)	(0.417)
Intellectual eminence: Rank 25-50%	1.009*	0.939*	0.912*
	(0.397)	(0.401)	(0.399)
Intellectual eminence: Rank 50-75%	0.041	0.068	0.023
	(0.458)	(0.457)	(0.457)
Education Field; General	3.610***	3.367***	3.123**
	(1.028)	(1.016)	(1.009)
Education Field; Education	-0.024	-0.107	-0.025
	(0.159)	(0.164)	(0.165)
Education Field; Humanities and Arts	-0.577*	-0.628*	-0.568*
	(0.275)	(0.270)	(0.268)
Education Field; Social Sciences, Business and Law	1.279	0.416	0.191
	(1.003)	(1.052)	(1.053)
Education Field; Sciences	0.955	0.884	0.975
	(1.227)	(1.261)	(1.256)
Education Field; Engineering, Manufacturing and Construction	1.586*	1.704*	1.537*
	(0.772)	(0.769)	(0.767)
Education Field; Agriculture	0.028	-0.001	0.013
	(0.155)	(0.152)	(0.151)
Education Field; Health and Welfare	-0.836+	-0.510	-0.630
	(0.478)	(0.480)	(0.480)
Education Field; Services	-0.187	0.141	0.121
	(0.169)	(0.189)	(0.187)
GDP per capita	2.424***	3.145***	3.406***
	(0.625)	(0.623)	(0.607)
Investment freedom	-0.004	-0.013+	-0.012+
	(0.008)	(0.007)	(0.007)
Constant	-48.445***	-50.906***	-53.213***
	(6.960)	(6.724)	(6.562)
Lnalpha	-0.896*	-1.124**	-1.230**
	(0.365)	(0.422)	(0.453)
Variance of intercept	0.042	0.010	0.005
	(0.047)	(0.032)	(0.027)
Observations	2,405	2,405	2,405
Number of groups	39	39	39
Log likelihood	-666.1	-660.4	-657.6
Chi2	482.8***	528.5***	547.4***

Standard error is in parentheses. p < 0.001***; p<0.01**; p<0.05*; p<0.1+. Observations are grouped per country-year. a: measured by the ratio between number of years in which professor has privilege and 13-year observation time.

Appendix B-2 Results of Multilevel Negative Binomial Regression: Spin-off Quality

	Model 4b	Model 5b	Model 6b
TTO establishment		-0.344+	-0.084
		(0.197)	(0.230)
IPR Institutional variance [a]		-0.558**	-0.146
		(0.177)	(0.244)
TTO X Institutional variance			-0.561*
			(0.244)
Cumulative entry	0.012***	0.012***	0.011***
	(0.003)	(0.003)	(0.003)
Industrial variance	0.117***	0.125***	0.130***
	(0.032)	(0.031)	(0.030)
Foundation year	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
Size	1.309***	0.961***	0.917***
	(0.195)	(0.230)	(0.225)
Sponsored research expenditure	0.138	0.240*	0.283**
	(0.088)	(0.102)	(0.102)
Intellectual eminence: Rank top 25%	1.077**	1.010*	1.015*
	(0.415)	(0.421)	(0.417)
Intellectual eminence: Rank 25-50%	1.009*	0.934*	0.910*
	(0.397)	(0.401)	(0.399)
Intellectual eminence: Rank 50-75%	0.041	0.061	0.020
	(0.458)	(0.457)	(0.457)
Education Field; General	3.610***	3.327**	3.114**
	(1.028)	(1.017)	(1.010)
Education Field; Education	-0.024	-0.108	-0.029
	(0.159)	(0.164)	(0.165)
Education Field; Humanities and Arts	-0.577*	-0.617*	-0.564*
	(0.275)	(0.270)	(0.268)
Education Field; Social Sciences, Business and Law	1.279	0.393	0.174
	(1.003)	(1.055)	(1.057)
Education Field; Sciences	0.955	0.885	0.976
	(1.227)	(1.262)	(1.257)
Education Field; Engineering, Manufacturing and Construction	1.586*	1.698*	1.541*
	(0.772)	(0.769)	(0.767)
Education Field; Agriculture	0.028	0.005	0.017
	(0.155)	(0.152)	(0.151)
Education Field; Health and Welfare	-0.836+	-0.508	-0.621
	(0.478)	(0.480)	(0.481)
Education Field; Services	-0.187	0.147	0.127
	(0.169)	(0.190)	(0.188)
GDP per capita	2.424***	3.006***	3.217***
	(0.625)	(0.618)	(0.602)
Investment freedom	-0.004	-0.012+	-0.011
	(0.008)	(0.007)	(0.007)
Constant	-48.44***	-49.40***	-51.21***
	(6.960)	(6.766)	(6.601)
Lnalpha	-0.896*	-1.130**	-1.221**
	(0.365)	(0.425)	(0.451)
Variance of intercept	0.042	0.012	0.008
	(0.047)	(0.032)	(0.029)
Observations	2,405	2,405	2,405
Number of groups	39	39	39
Log likelihood	-666.1	-660.4	-657.9
Chi2	482.8***	528.0***	544.8***

Standard error is in parentheses. p < 0.001***; p<0.01**; p<0.05*; p<0.1+. Observations are grouped per country-year. a: measured by absolute number of changes in IPR institution in a country.