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What drives the formation of 'valuable' University-Industry linkages?
An under-explored question in a hot policy debate

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What drives the formation of 'valuable' University-Industry linkages? An under-explored question in a hot policy debate

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Abstract

Most of the literature on University-Industry (U-I) linkages assuming that these linkages will be beneficial *per se*. We question this assumption and suggest that not all U-I linkages are equally 'valuable'. In this paper, we explore the factors driving to the formation of 'valuable' U-I linkages, conceived as those that have a higher potential to diffuse knowledge to other firms in the economy. We estimate a two-stage Heckman model using data from two wine clusters in Chile and in Italy. The quality of firms and universities is found to be a key driver of 'valuable' U-I linkages. We conclude that selectivity by policy-makers should be encouraged when they promote U-I linkages.

Key words: University-Industry linkages, knowledge diffusion, social network analysis, wine, Chile, Italy.

JEL Codes: O33; O31; L66

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1. Introduction

Universities are increasingly considered central actors in the process of economic development of countries and regions. In recent times, their direct involvement with industry has increased and policies have been designed to promote University-Industry (U-I) networking. However, this enthusiasm raises concerns about the costs and time-consumption of U-I networking that may be detrimental to university research. Advocates of this latter view would suggest that, first, university research has a value *per se*, independently on whether it connects to the industry or not, because it keeps alive curiosity-led investigation which is a cultural value worth transmitting to the next generation. Second, universities that link up to industry too intensively become more interested in industry-driven short-term problem-solving research – an aspect that might undermine researchers' intellectual freedom in both the definition of their research agenda and in the way research results are used. This tension has recently sparked a debate on whether U-I linkages should be promoted or not, which has important implications for policy-making (see for example Poyago-Theotoky, *et al.*, 2002).

We believe there are benefits and costs involved in the U-I relations and therefore we acknowledge the relevance of that debate. However, our viewpoint is constructive and we will avoid the attempt to classify U-I linkages as something to be supported or limited. Instead, we argue that some U-I linkages are more valuable than others, in that they can have a higher potential to diffuse 'knowledge', thus generating positive effects on the economy.[1] In the spirit of the above debate, we then argue that, from a policy-making perspective, it would be desirable to support only the creation of 'valuable' linkages. But, *what factors favour the formation of valuable U-I linkages?* We think this to be a very important but under-explored question, as the literature tends to simply focus on what affects the formation of U-I linkages, assuming that these will *per se* have a beneficial effect.

More specifically, our interest here is to explore the factors that influence the formation of linkages between universities and firms that are more likely to diffuse their knowledge to other firms located in the same

[1] With the term 'knowledge' we mean here "a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experience and information. It originates and is applied in the minds of knowers" (Davenport and Prusak, 2000: 5) Therefore, interaction between agents increase the potential of knowledge diffusion.

regional cluster (hence when this occurs, we consider the U-I linkage to be 'valuable'). To explore this question, we use an original dataset of wine producers in two wine producing areas, in Chile and Italy. We analyse the data applying Heckman two-stage selection model, so that, first we estimate probability of forming U-I linkage, second, we estimate the degree of knowledge diffusion of any formed linkage in the regional cluster.

The paper is organised as follows: Section 2 presents the conceptual framework and the elaboration of the research hypotheses. Section 3 illustrates the context in which the research was set and the methodology. Section 4 presents empirical results and Section 5 concludes.

2. Conceptual framework

2.1 Fortifying University-Industry linkages? An open debate

For those interested in economic development, the role that universities can play in enhancing regional and national innovations systems is certainly a matter of great and increasing interest. In effects, several studies have suggested that universities can be central players in an economic system (Charles, 2003, Cooke, 2001, Dasgupta and David, 1994, Kitagawa, 2004, Lundvall, 1992, Nelson, 1993, Nelson, 2004, Salter and Martin, 2001). Also, scholars have promoted the idea that universities should go beyond their traditional teaching and research activities, and undertake a 'third mission', aimed at a more direct interaction and contribution to the industry (Etzkowitz and Leydesdor, 2000, Slaughter and Leslie, 1997).

A growing number of studies have documented the existence and the drivers of the formation of linkages between universities and industry (Anselin, *et al.*, 2000, Arundel and Geuna, 2004, Bonaccorsi and Piccaluga, 1994, Cohen, *et al.*, 2002, Fontana, *et al.*, 2006, Fritsch and Schwirten, 1999, Geuna, 2001, Gregorio and Shane, 2003, Hall, *et al.*, 2003, Kaufmann and Todtling, 2001, Link, 2002, Meyer-Krahmer and Schmoch, 1998, Mowery, *et al.*, 2001, Santoro and Chakrabarti, 1999, Slaughter, *et al.*, 2002, Tornquist and Kallsen, 1994, Van Looy, *et al.*, 2003, Velho and Saez, 2002). These studies have highlighted that there are a number of different ways through which U-I linkages are formed: including the employment of university graduates in the industry, informal meetings, joint research programmes, consultancy work commissioned by the industry and not involving original research, licensing of university patents, purchase of prototypes developed by the industry, etc. (e.g Cohen, *et al.*, 2002, D'Este and Patel, 2007, Meyer-Krahmer and Schmoch, 1998, Schartinger, *et al.*, 2002, Slaughter, *et al.*, 2002). More interestingly, many of these studies have attempted to identify firms, industries, universities' characteristics that affect the probability of forming U-I linkages (e.g. Anselin, *et al.*, 2000, Arundel and Geuna, 2004, Cohen, *et al.*, 2002, Fontana, *et al.*, 2006, Jaffe, 1989, Lee, 1996, Santoro and Chakrabarti, 1999, Tornquist and Kallsen, 1994), while other works analyse the extent to which they are beneficial for firms' innovative performance (e.g. Kaufmann and Todtling, 2001).

Enthusiastic views about the importance of U-I linkages are counterbalanced by several voices raising concerns related to (i) the goals of public research and (ii) the appropriation and use of research outputs. These views usually support the historical role of universities as generators of public knowledge. Regarding (i), the main issue is whether public research should be devoted to solve concrete problems in the industry. This is argued under the presumption that it undermines researchers' intellectual freedom, in both the definition of their research agenda, and, in the way the results of researches are used and made public (Blumenthal, *et al.*, 1997, Louis, *et al.*, 2001, Nelson, 2004, Tapper and Salter, 1995). This, in turn, is considered to harm the creative potential of universities over the long term. Thus, U-I linkages are seen as a time-consuming and a distracting/costly activity, which can be detrimental for university research (Crespo and Dridi, 2007, Slaughter and Leslie, 1997). In effect, universities that link up to industry too intensively may become more interested in short-term, consultancy-based research, rather than in long-term fundamental quests. Furthermore, some authors also highlight that the alternative sources of funds created within universities, via their relationship with the industry, reduce governments' responsibility for the economic support of university research – a condition that may favour applied research activities against basic science (Lee, 1996) or may bias research agendas towards profitable research activities. As concerns the appropriation and use of knowledge (ii), the problem arises because companies usually want exclusive rights on their inventions, while public universities' priority should be the wide diffusion of publicly created knowledge (Jelinek and Markham, 2007, Pickering, *et al.*, 1999, Santoro and Chakrabarti, 1999, Slaughter, *et al.*, 2002).

In some places, this tension has even sparked intense reactions against policies promoting U-I linkages (see for example, De Sousa Santos, 2006, Llomovatte*, et al.*, 2006). This paper contributes to this debate by contending that, for the reasons explained above, the formation of U-I linkages carries an important opportunity-cost for universities. This opportunity-cost is not only affecting university researchers, but, indirectly, it could have an impact on the overall economic system – e.g. in terms of less public knowledge generation or, in the case of developing countries, of diverting lines of research away from development policy goals. For this reason, we feel that, from a policy-making perspective, it could be more desirable to foster U-I linkages that have a higher potential of generating knowledge spillovers (i.e. 'valuable' linkages), while hindering other, potentially less valuable, ones. Here lies our research question: *what factors favour the formation of 'valuable' U-I linkages?* We think this is a very important yet under-explored question. In fact, to the best of our knowledge, the literature has not yet attempted to identify factors that affect the *quality* of U-I Links, instead, it tends to simply focus on what affects the formation of U-I linkages, assuming that these will *per se* have a beneficial effect.

2.2 The drivers of 'valuable' U-I linkages: a model

In this section, we develop a set of research hypotheses about the factors that could affect, first, the formation of U-I linkages (2.2.1) and, second, the transfer of knowledge by firms with U-I linkages to other firms in their regional cluster – leading to the formation of 'valuable' linkages (2.2.2).

2.2.1 Factors affecting the formation of U-I linkages

In line with most of the recent literature, we consider both firm-level and university-level factors that can be associated with a higher propensity to form U-I linkages:

(a) Firms' knowledge bases

Several studies have explored how firms' characteristics affect the formation of different types of linkages to universities and public research organisations (Arundel and Geuna, 2004, Cohen, *et al.*, 2002, Fontana, *et al.*, 2003, Laursen and Salter, 2004). Our main interest here is on a key dimension of firms' internal characteristics: the knowledge base (KB), defined here as the “set of information inputs, knowledge and capabilities that inventors draw on when looking for innovative solutions” (Dosi, 1988: p. 1126), see also Giuliani (2007a). Knowledge is seen as residing in skilled knowledge workers in the firms and it is accrued and generated through their experimentation effort, both to exploit and to explore new ways to solve problems (Nelson and Winter, 1982)

We believe that this an important variable to explain the formation of U-I linkages, because firms with stronger knowledge bases, by way of their enhanced absorptive capacity (Cohen and Levinthal, 1990), have more capabilities to search and exploit valuable external knowledge. Universities are one such external source of knowledge. Several studies also corroborate this view, showing that e.g. firms with higher R&D intensity have more university collaborations (Arundel and Geuna, 2004, Fontana, *et al.*, 2003, Schartinger, *et al.*, 2002). Hence, we formulate our hypothesis as follows:

> **Hypothesis 1** The stronger the firm knowledge base, the higher will be the probability that the firm forms linkages with university and other public research organisations.

(b) University departments’ scientific quality

The propensity to form U-I linkages also depends on the characteristics of university departments. Mowery and Sampat (2004), for example, suggest that public research organisations vary in their structure, size and strategies and therefore should not be considered as homogeneous entities. Here we consider a key aspect of university departments: their scientific quality. In their seminal work, Mansfield and Lee (1996) have looked at whether the quality of universities affects the likelihood of them being linked and supported by the industry. They found that top four US universities gathered a significant number of linkages to the industry, observed by asking firms to cite academic researchers whose work in the previous decade contributed most importantly to the firm’s new products and processes.

However, they also observed that second tier universities, with low-quality academic records, displayed significant interactions to the industry, especially on applied R&D and with nearby firms (p. 1055). In line with this second result, a more recent study (D'Este and Patel, 2007), based on UK data, found that, in the case of applied disciplines, poorly rated university departments seem to engage in a wide range of U-I interactions. This is considered to be due to two main reasons: First, lower quality departments could have more limited access to public funding (especially in systems where public research funds are allocated on the basis of research assessment exercises), making it necessary for them to find research funding from industry. Second, lower quality departments may employ researchers with limited interest or ability to undertake 'blue sky' research, and who prefer less ambitious, and more problem-solving research for the industry. On the basis of this, the following hypothesis is formulated:

> **Hypothesis 2**: University departments with lower scientific rating have higher probability of linking to industry.

2.2.2 Factors affecting the diffusion of knowledge by firms with U-I linkages

In this section, we discuss what makes an U-I linkage 'valuable', at least in the geographic context where the firm operates – i.e. its regional industrial cluster.[2] As suggested in Section 1, U-I linkages are considered 'valuable' when a firm holding a linkage to a university contributes to diffuse its knowledge to other firms in its cluster, by way of the direct and indirect knowledge ties it establishes informally with them, for e.g. solving technical problems (von Hippel, 1987).[3] By contrast, U-I linkages have little value if they are formed by firm that act as 'dead ends' in the U-I knowledge pipeline, that is, by firms that, in spite of having linkages to universities, do not contribute to diffuse their knowledge to other firms in the cluster (see also Bell and Giuliani, 2007).[4]

Previous research on wine clusters has shown that there is a relationship between the propensity of firms to establish knowledge linkages to other cluster firms and their relative strength of firm knowledge bases in the cluster. For example, Giuliani (2007a) , using micro-level data on fine wine producers in three wine clusters

[2] An industrial cluster is defined here as a geographical agglomeration of firms operating in the same industry, in line with the definition given by Humphrey and Schmitz (1996). Sometimes scholars have defined this type of industrial agglomeration as industrial district.
[3] Numerous studies have documented the horizontal transfer of technical knowledge, and analysed the incentives and motivation that drive the exchange technical knowledge among rival firms (see e.g. Bouty, 2000, Powell, *et al.*, 1996, Schrader, 1991).
[4] We make the reasonable assumption that, among the firms that maintain linkages to universities, those that have knowledge linkages to other firms in their regional cluster have more potential to diffuse university-generated knowledge, than those that have little or no linkages at all.

located in Italy and Chile, has illustrated that firms with stronger knowledge bases transfer more innovation-related knowledge with other firms in the cluster. This is because these firms may be perceived by other cluster firms as 'technological leaders' in the local area, leading to their being sought out as sources of innovation-related advice and knowledge more often than firms with weaker knowledge bases. On the basis of this work, we develop the following research hypothesis:

> **Hypothesis 3** The strongest the firm knowledge base of firms with U-I linkages, the higher their potential to diffuse knowledge to other firms in the cluster.

3. Methodology

3.1 The context

3.1.1 The wine industry

This study is contextualised in the wine industry, which has recently faced striking worldwide transformations, both in the characteristics of the markets and in the production of wine (Archibugi, 2007). While a comprehensive discussion about the wine industry is beyond the scope of this paper, we point out here to the most significant changes occurred in the industry since the 1990s: **first**, the traditional Mediterranean wine-producing countries (i.e. Italy, France, Spain and Portugal) have been challenged by producers in other continents: Australia, South Africa, the USA, Argentina, and Chile among others, which have become major producers and exporters of wine (for statistics, see Anderson and Norman, 2001; Smith, 2007). **Second**, the total volume of wine produced is declining, but at the same time, the total value of production is increasing, which suggests that consumers drink less wine but of higher unit price (Archibugi, 2007). Also, new countries emerged in the international demand of wine, such as the UK, or the Asian countries (Anderson and Norman, 2001). **Third**, the higher unit price reflects an increase in the quality of wine. As Archibugi (2007) suggests "the era in which a litre of honest un-bottled table wine was cheaper than a litre of gasoline still exists in Italian, French and Spanish towns, but is drawing to a close." (p. 125). Thus, the intrinsic quality of wine has improved in absolute terms with respect to the past – even if differences exist across market segments.

A key aspect that makes the wine industry an appropriate context for testing our research hypotheses is the importance of innovation and university research for the improvement of the industry. There is in fact a widespread consensus that this improvement in wine quality has been achieved through the introduction of substantial innovations in the techniques of production (see e.g. Giuliani, 2007b, Smith, 2007, McDermott et al., 2007). More importantly, several studies have documented that university research plays an important role in transferring to firms critical knowledge generated by basic and applied research (see Aylward, 2003, Loubere, 1990, Morrison and Rabellotti, 2007, Smith, 2007, McDermott et al., 2007).[5]

3.1.2 The two wine clusters

This study is focused on two countries: Italy and Chile. It looks at U-I linkages between **national universities** (and/or public research organisations) **and** wine producers located within a **regional wine cluster** – i.e. Bolgheri/Val di Cornia in Italy and Valle de Colchagua in Chile. The characteristics of these two wine clusters have been described elsewhere by one of the authors (see e.g. Bell and Giuliani, 2007, Giuliani, 2007a). Here we will just briefly point out that, in spite of being located in two very different countries, these clusters shared some fundamental characteristics. They were of similar size (in both cases the overall areas are about 50 Km from north to south), and both densely populated by fine wine producers and grape growers. The degree of vertical division of labour is rather low, with no other relevant suppliers located within the clusters' territories. Each cluster includes a business association, whose primary aim is the promotion of wines and the marketing of the local wine route, while other actors (universities, suppliers, clients, etc.) are all located outside the cluster's boundaries. Finally, both clusters have a long history of wine production, but experienced economic growth only after the 1980s, when worldwide consumption of high quality wines began to grow.

[5] Scientists have historically played a key innovative role in the wine industry. As an example, after the 1860s' phylloxera outbreak: "science played a large role in the constitution of the devastated vineyards, and especially in the preservation of quality wines from *vinifera* vines" (Paul, 1996 pp. 10-11).

3.2 Data collection

This study is based on micro level data collected at the firm level in the two wine clusters on the basis of interviews, carried out with the skilled workers (i.e. oenologists or agronomists) in charge of the production process at plant level in the firms in these clusters. The survey was carried out in 2002 and was addressed to the entire population of producers of fine wines in the two clusters, which numbered 41 in Bolgheri/Val di Cornia (Italy) and 32 in Valle de Colchagua (Chile), making a total of 73 firms.[6]

Apart from general background and contextual information, the interviews were designed to obtain information that would permit the development of quantitative indicators in three key areas:

(i) the firms' knowledge linkages with national universities or other public research organisations;[7]

(ii) the firms' knowledge linkages with other firms in their regional cluster;[8]

(iii) a set of variables about firms' characteristics, which permitted the operationalisation of key concepts (e.g. firm knowledge base).[9]

Furthermore, we collected key information about each of the university departments that have at least one connection to a firm in the cluster.[10] In particular, we collected information about (i) the quantity and quality

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[6] Grape-growers are not part of this study. More details on this are found in Giuliani and Bell (2005).

[7] Respondents were provided with a roster that included a number of specific institutions, e.g. particular universities, and other public research organizations that appeared to be relevant during pilot fieldwork, and they were asked the following two questions: (1) Could you mark, among the actors included in the roster, those that have transferred relevant technical knowledge to this firm? (2) Could you mark, among the actors included in the roster, those with whom this firm has collaborated in research projects during the last two years? Respondents were also left free to add relevant universities and public research organisations that were not included ex-ante in the list.

[8] The collection of relational data was based on a roster study and on the following two questions: (1) "If you are in a critical situation and need technical advice, to which of the local firms mentioned in the roster do you turn?" and (2) "Which of the following firms do you think have benefited from technical support from this firm?". Further details can be found in Giuliani and Bell (2005) and Giuliani (2007a) .

[9] The questionnaire included questions about (1) the number of technical employees with a graduate degree (BSc, MSc, MPhil, Dhil) in technical disciplines; (2) Maximum grade of education obtained (BSc, MSc, MPhil, DPhil); (3) Number of months spent employed by firms in the wine industry, specifying if domestic or foreign firms; (4) whether the firm carried out experimentation, which type and in which areas of the production process has such experimentation was carried out.

of scientific research of the universities, gathered through the ISI Web of Knowledge Science Citation Index Expanded – 1954 to present[11] and (ii) the geographical distance to the industry cluster. For the former type of data, the search criteria has been the name of single departments within each university, whose discipline was connected to the agronomics or oenological fields, thus, for example, the search for the University of Florence included the Interfaculty Department of Vegetal Biology, the Department of Agronomic Engineering, the Department of Soil and Plant Nutrition, the Department of Agrarian Biotechnologies, and so on (a full list of the departments searched for each university is provided in the Appendix I).[12] The selection criteria was designed in a way to dispose of all the publications whose content was about human beings or animals or it was explicitly about non-industry relevant vegetal species (e.g. potato, tomato, beans and the like).

3.3 Operationalisation of variables

3.3.1 Dependent variables

This paper aims at identifying factors that affect the formation of 'valuable' U-I linkages. As discussed later in Section 3.4, our research question has required a two-stage estimation process, which in turns requires the development of two types of dependent variables. First, (i) a measure of U-I linkages , and second (ii) a measure of the degree to which firms with at least an U-I linkage diffuse their knowledge to other firms in their regional cluster. The two variables have been developed as follows:

(i) *UI LINK* measures the existence of a linkage between firm (*i*) and a university (*u*). It is a binary variable that takes the value of 1 if firm (*i*) has at least one linkage with the university

[10] In the Chilean case, these turned out to be the University of Chile, the Catholic University in Santiago, the University of Talca and the Instituto Nacional de Investigacion Agropecuaria (INIA). In the Italian case the relevant universities and public research organisations were the Universities of Pisa, Florence and Milan, as well as *the Istituto Vitivinicolo di Conegliano Veneto* and the Agenzia Regionale per lo Sviluppo e l'Innovazione nel settore Agro-forestale (ARSIA).

[11] Using publications and citations in ISI journals as measures of output and impact provides comprehensive and consistent metrics for all researchers. However, it is equally important to stress that relying on these metrics also results in limitations for the study. In fact, it misses relevant outputs of research, such as books, patents and publications in journals not listed in the ISI database.

[12] In the search process, double checks have been performed also by searching the name of researchers listed in each selected department's web page.

(*u*). This variable includes two types of linkages: those formed for joint research and those formed through the transfer of technical knowledge from university to industry (see questions mentioned in footnote 7).

(ii) *DIFFUSION* measures the degree to which a firm with at least a linkage to a university (*UI LINK*=1) could diffuse innovation-related knowledge to other firms in the regional cluster. To compute the diffusion of knowledge into the local cluster, we used a standard measure of social network centrality, known as Out-Closeness (Freeman, 1979, Wasserman and Faust, 1994), calculated from responses to the questions reported at footnote 8 (see also Giuliani, 2007a for a reference).This measure (hereinafter *OUT-CLOS*) is slightly more sophisticated than other measures of centrality as it takes into account, not only the direct number of linkages established with other firms (as e.g. for degree centrality), but the extent to which the firm manages to 'reach' other firms in the cluster, that are not directly connected to it. To understand it, we need to think about knowledge diffusion as a multi-step process, so that a distinctive piece of knowledge goes from firm *(i)* to its direct contacts (called 'alters') and from the alters to other firms (Rogers, 1983). According to how many direct connections firm *(i)* has, and also to the connections that its alters establish, firm *(i)* can be more or less close from the other firms. A firm has high *OUT-CLOS* when it can reach the rest of the firms through the minimum number of steps. In technical terms, Out-Closeness is measured as the reciprocal of the sum of the shortest paths (called geodesics) between a firm *(i)* and other firms in the network. The measure has been standardized as data come from networks of two different sizes and structures. Standardization is carried out by dividing this value by the maximum value of closeness obtained for that specific network. Isolated nodes take the value of 0. The indicator has been computed by UCINET (Borgatti, *et al.*, 2002) and details about its measurement can be found in Wasserman and Faust (1994).

We use this measure as an indicator of knowledge 'diffusion', because it captures, not only knowledge transfer through the direct linkages with alters, but also the degree to which the knowledge transferred to the alters can potentially reach other firms with a limited number of steps. In fact, this is a critical aspect because the higher the number of steps in the diffusion process, the higher the downgrading of the knowledge transferred by the original firm.[13] Hence, our measure of *DIFFUSION* is thus calculated as follows:

DIFFUSION = UI LINK OUT-CLOS.*

It is thus a truncated variable that takes positive values only when firms are connected to at least a university (i.e. *UI LINK* = 1).

3.3.2 Independent Variables

(a) Firm knowledge base (*KB*)

Hypotheses 1 and 3 test the impact of firm *KB* on their likelihood to be connected to universities (HP 1) and to diffuse knowledge to other firms in the cluster (HP 3). We are aware of the problems of endogeneity that similar variables – e.g. R&D – generate when estimating the effects on the formation of linkages or on different types of innovative output (e.g. Cassiman and Veugelers, 2002, Veugelers and Cassiman, 2005). However, we operationalise firm knowledge base using stock variables rather than flows, as it is often the case. In this way, we minimise the possible effect of the endogeneity mentioned above.

Consistent with previous studies using the same set of data (e.g. Giuliani, 2007a, Giuliani and Bell, 2005), the measure of *KB* is a composite indicator of three dimensions of the firm knowledge base: (i) human resources' formal training, (ii) human resources' experience in the field and (iii) firm's experimentation intensity. While (i) and (ii) refer to human resources at the time the interviews took place (2002), (iii) takes into account the experimentation activities carried out up to two years prior the interviews. This is because pilot fieldwork has revealed that two years is a good time span to have an idea of the intensity of experimentation carried out by a wine producer. These variables were defined as follows:

[13] By definition, all connections in the network imply some degree of knowledge transmission. However, knowledge transferred by firms connected to universities to other firms in their cluster may not have necessarily originated from *within* the university. It could have originated elsewhere (e.g. by internal exploration of the firm or through other types of connections). Nevertheless, among the firms that maintain linkages to universities, it is reasonable that those that have higher out-closeness have more potential to diffuse university-generated knowledge.

(i) Human resources' formal training (HR): it represents the cognitive background of each firms' knowledge skilled workers on the of their degree of education. According to previous studies regarding returns to education, we assume that the higher the degree of education the higher is their contribution to the economic returns of the firm. On this assumption we weight each knowledge skilled worker differently according to the degree attained so that:

Human Resource (HR) = 0.8 Degree + 0, 05* Master + 0,15* Doctorate*

A weight of 0.8 has been applied to the number of graduate employees in the firm which include also those that received higher levels of specialisation. In such cases the value adds up a further 0.05 times the number of employees with masters and 0.15 for those that have a Ph.D. Also, only degrees and higher levels of specialisation in technical and scientific fields related to the activity of wine production (i.e agronomics, chemistry, etc.) are taken into account.

(ii) Human resources' experience (MONTHS): it represents the working experience of each of the abovementioned resources in temporal terms. Time is in fact at least indicative of the fact that accumulation of knowledge has occurred via 'learning by doing'. More in detail, the variable is the result of a weighted mean of the months of work of each knowledge skilled worker in the country and abroad:

Months of Experience in the Sector (MONTHS)= 0,4 n° months (national)+ 0,6* n° months (international)*

To the time spent professionally abroad we attributed a higher weight because the diversity of the professional environment might stimulate an active learning behaviour and a steeper learning curve. The learning experiences considered are those realised in the wine industry only.

(iii) Experimentation (EXPE):

Experimentation intensity is a proxy for knowledge creation efforts. This has been measured on a scale ranging from 0 to 4, according to the number of areas in which the experimentation is carried out by a firm: for example, if a firm experiments in all the production phases, from the introduction of different clones or varieties in the vineyard 'terroir', the management of the irrigation and vine training systems, and the fermentation techniques and enzyme and yeast analysis, to, finally, the ageing period analysis, this firm will get a score of four in its experimentation intensity. In contrast, a firm with no in-house experimentation will have a zero.

Although these variables measure different aspects of the firms' knowledge bases, they are highly correlated - especially *HR* and *MONTHS* (> 0.7 in both countries, see Table 1-a). The high correlation of the variables justifies the need to construct a composite indicator of firms' knowledge bases, which we did using factor analysis. This technique is used to discover underlying dimensions (called factors) that could explain largely or entirely the behaviour of larger number of observed variables. We use the Principal Component (PC) method to extract factors, since our aim is to *summarise* the behaviour of the three above-mentioned variables in a single one, which will be interpreted as representative of firms' knowledge bases.[14] PC analysis was carried out separately for Chile and Italy. One single factor was extracted in each case, which in both cases represented 73% of data variation. We have then named the factor as firm Knowledge Base (*KB*). Factor loadings and uniqueness are reported in Table 1-b.

[14] Factor analysis, requires ratio or interval data, which is not the case for our ordinal *EXPE*. The restrictive assumption we must make is that distances between ordinal values are sensitive to measure intensity and the same meter applies to all respondents.

Table 1 Statistics on principal component analysis of the components of firms' knowledge bases

Chile			Italy		
a) Correlation matrices					
	HR	*MONTHS*		*HR*	*MONTHS*
MONTHS	0.79		*MONTHS*	0.72	
EXPE	0.45	0.54	*EXPE*	0.61	0.46
b) Main statistics on factor analysis					
	Factor Loadings	Uniqueness		Factor Loadings	Uniqueness
HR	0.89	0.21	*HR*	0.92	0.16
MONTHS	0.92	0.15	*MONTHS*	0.85	0.27
EXPE	0.75	0.43	*EXPE*	0.80	0.37

(b) Scientific quality (*UQUAL*)

As an indicator of university's scientific quality we have considered the number of citations received by each university's publications in the departments listed in Appendix I and for publications that have been done in wine-related fields. Hence, *UQUAL* is a measure of the number of citations received by ISI articles, excluding the authors' self-citations. This variable is normalised by the number of ISI publications produced by the university and by the number of years since publication – thus controlling for the fact that older publications are more likely to have more citations by an effect of time, rather than relative quality.

3.3.3 Control Variables

In the estimations we use a set of control variables that are associated by the literature to our dependent variables. As concerns firm-level variables, we consider:

- → size of the firm, measured by the number of employees in 2002 (*FSIZE*);
- → age of the firm, measured as the number of years since the start of operations, to 2002 (*AGE*);
- → ownership, which is a dummy variable indicating whether the firm is foreign- (1) or domestic-owned (0) (*OWN*);
- → type of organization since firms in the clusters have three different types of organizational structures: *ORG1* corresponds to firms that are independently owned and that perform all production phases in the cluster in which the headquarters is also located; ORG 2 refers to firms that are vertically integrated and thus perform all phases of the production process

within the cluster; and *ORG3* are firms that are vertically disintegrated and thus perform only part of the production process, usually grape-growing, within the cluster.

→ Share of exports (*EXPORT*), which is measured as the percentage of sales that are exported by the firm;

As concerns universities, we control for the geographic distance of the university from the industry because scholars have shown that the geographic proximity between universities and the industry favours the interaction and the generation of knowledge flows (e.g. Abramovsky, *et al.*, 2007, Anselin, *et al.*, 2000, Arundel and Geuna, 2004, Jaffe, 1989). We measure this by the distance (in kilometres) between the cluster (considering the location of its main village) and the town or city where the university is located. Also, we control for the size of the university, but we do not have information about number of employees in 2002 (or other direct measures of size). Hence, we use a very rough measure of scale, taking into account the total number of publications appeared in the ISI Web of Knowledge Science Citation Index Expanded – 1954 to present for each university (*USCALE*). This is a cumulative variable that takes into account the amount of research that has been undertaken historically by a given university.[15]

3.4. Main characteristics of each cluster

Table 2 describes mean values of all variables to be used in the estimations so as to characterise each cluster. The table suggests that there are some differences between Chilean and Italian firms. In particular, in the Chilean cluster the proportion of foreign-owned firms is significantly higher than in Italy; Chilean firms are larger, export more, have higher indicators of *KB*, especially in the quality of their skilled human resources (*HR*, *MONTHS*). Also, on average, Chilean firms show significantly higher values for *OUT-CLOS* than Italian firms.

In contrast, Italian universities are bigger and show higher scientific records (*UQUAL*), than Chilean ones. This is in part expected given the indicators used to measure quantity and quality. It is likely that higher opportunities to publish internationally were available to Italian universities, given their location in Europe, especially when compared to a South American country.

[15] Please note that this variable is highly correlated with the number of researchers having an ISI publication in the universities considered for this study (Person coefficient for Chile: 0.98 and for Italy: 0.99). Hence, we can reasonably argue that the number of publications also reflect the number of researchers involved in it.

Finally, on average, the distance between the regional cluster and the universities is 170 Km in Chile and 147 Km in Italy. In Chile, three out of the four universities included in the study locate in the capital city, thus dispersion in the length of distance is rather small. The coefficient of variation is only 7%. In contrast, in Italy, universities are much more dispersed, which implies a higher variance in the geographical distance (the coefficient of variation is 79%).

Table 2 Descriptive statistics about firms and universities in the each cluster

		Chile	**Italy**	Sig
Firm level variables				
Number of Firms	Count	32	41	
Experience (MONTHS) (1)	Avg.	67.79	28.66	***
Human resources (HR) (1)	Avg.	1.71	0.45	***
Experimentation (EXPE) (1)	Avg.	1.59	1.10	***
No experimentation	Proportion	0.28	0.54	***
Low experimentation	Proportion	0.50	0.29	***
High experimentation	Proportion	0.22	0.17	
AGE	Years (Avg.)	25.44	25.46	
Type of firms				
Independent (ORG 1)	Proportion	0.22	0.07	***
Group: vertically integrated (ORG 2)	Proportion	0.13	0.00	***
Group: vertically desintegrated (ORG 3)	Proportion	0.66	0.93	***
Foreign firms (OWN)	Proportion	0.19	0.02	***
Exports over sales (EXPORT)	Avg. %	60.94	32.07	***
Employees (FSIZE)	Avg.	55.59	7.98	***
Connection to the cluster (OUT-CLOS) (1)	Avg.	10.43	6.58	***
University level variables				
Number of Universities	Count	4	5	
Scientific Quality (UQUAL) (1)	Avg.	0.47	0.76	***
University Scale (USCALE)	Publications (Avg.)	36.75	116.20	***
Geographical distance to universities for connected firms (GEOD)	Km (Avg.)	169.60	146.84	

(1) See methodology for definition.
*** Difference is significant at 1%, ** Difference is significant at 5%,* Difference is significant at 10%

3.4 Econometric estimation

As mentioned earlier, this paper explores two types of effects: first, the factors affecting the probability of formation of an U-I linkage (*UI LINK*), and, second, the factors affecting the degree of connectivity of firms linked to universities (*DIFFUSION*). As said above, *DIFFUSION* is variable whose observations only exist for firms connected to universities (i.e. it is a truncated variable). Moreover, *U-LINK* and *DIFFUSION* are not independent events. For all these reasons, it would have been inappropriate to use Probit or Logit models to estimate the former and an OLS model to estimate the latter. Therefore, we estimate a two-stage Heckman model, which estimates in a single model the probability of U-I linkage and the degree of knowledge diffusion.

In the first step, a Probit model estimates the likelihood of connecting to a university (Equation 1). This enables to estimate the expected residuals of *DIFFUSION*'s truncated observations, which are in turn used in the second step. This second step is a correct specification of an OLS estimation (Equation 2) (i.e. an OLS model for which selectivity has been controlled for). We estimate robust standard errors to account for heteroscedasticity.

(1) UI LINK= [KB, UQUAL, USCALE;GEOD, FSIZE, OWN, AGE; ORG2; ORG3]

(2) DIFFUSION =[KB; FSIZE, OWN, AGE; ORG2; ORG3; EXPORT]

This method requires to identify variables that have a significant effect on the first step (Equation 1) but do not affect the second step (Equation 2). We comply with this pre-requisite by including three variables related to university's characteristics, which should not affect the degree of a firm's connection to the cluster, but would affect the likelihood of connection to an university. Thus, Equation 1 includes most of the firms' characteristics also included in Equation (2), which have been previously identified in the literature as important factors to address U-I linkages, plus university scientific quality (*UQUAL*), geographic distance with the industry (*GEOD*) and a control for university size (*USCALE*).

4. Empirical results

4.1 Descriptive statistics

Table 3 reports descriptive statistics about the differences existing between firms that have established linkages to universities and firm that have not. It shows that both in Chile and in Italy, about two thirds of the firms in the cluster maintain at least one linkage to a university (23 firms out of 32 in Chile and 27 firms out of 41in Italy). [16] The comparison is done systematically for both countries.

In Table 3-a, we report the mean values or the distribution of a number of firm-level characteristics, according to whether they have or not established U-I linkages, also indicating where differences are statistically significant. The first striking result is that differences across firms with and without U-I linkages are much more marked in Chile than in Italy. In Chile, firms with U-I linkages have stronger knowledge bases, reflected in the training and experience of human resources and in the experimentation; they are also significantly younger, of larger size, tend to be independent, export a larger share of their sales. In Italy, in contrast, firms that connect to universities are not significantly different from those that do not. The only significant difference is related to experimentation: those firms that experiment a little are more likely to be connected than otherwise. No difference was found, though, across firms with high experimentation intensity. Also, it is interesting to note that firms that connect to universities do also have higher *OUT-CLOS* values in the Chilean cluster (14.49 for firms with U-I linkages vs. 7.65 for firms without U-I linkages), while this is not the case in Italy (*OUT-CLOS* is around 7 in both cases).

In relation to the characteristics of universities, Table 3-b shows that, in Chile, firms with U-I linkages seem to connect more with larger universities and to those characterised by higher scientific quality. In Italy, instead, the universities that have formed more linkages to the industry appear to be those with the lowest scientific records, whereas university's size is fairly the same for those that connect and do not connect. In both countries, it is interesting that universities that are more geographically proximate to the cluster turn

[16] Please note that these data should be interpreted with caution because the study includes only universities that were appointed by at least one firm. In order words, although our data include the population of wine producers in each cluster, our list of universities does not include the whole population of national universities. Thus, the expression U-I Link=0 refers to U-I linkages that have not been established between firm *(i)* in the cluster and the universities identified in the study by the rest of the firms *(j)*. In fact, it is often the case that a single firm establishes linkages with only one university and not with the whole set of universities included in the study .

out, on average, to have established more linkages to the industry. This evidence, however, must be interpreted with caution, as not every university that could have been connected to the industry was included in the sample but only those appointed by at least one firm in the cluster. In both clusters, this implies that more distant university are not taken as part of the universe, and, among universities included, most firms have established linkages to those that were closer.

Table 3: Descriptive statistics of variables included in the models

		Chile			**Italy**		
	Indicator	U-I Link=0	U-I Link=1	Sig	U-I Link=0	U-I Link=1	Sig
Number of firms	Count (%)	9 (28)	23 (72%)		14 (34%)	27 (66%)	
Number of U-I linkages (1)	Count (%)	76 (58%)	52 (42%)		160 (78%)	45 (22%)	
a) Firm level variables							
Number of Firms	Count	9	23		14	27	
Experience (MONTHS) (2)	Avg.	45.67	100.12	***	30.20	23.17	
Human resources (HR) (2)	Avg.	1.22	2.44	***	0.47	0.40	
Experimentation (EXPE) (2)	Avg.	1.07	2.37	***	1.06	1.22	
No experimentation	Proportion	0.42	0.08	***	0.57	0.42	*
Low experimentation	Proportion	0.49	0.52		0.25	0.44	**
High experimentation	Proportion	0.09	0.40	***	0.18	0.13	
Knowledge Base (KB)	Avg.	-0.36	0.53	***	0.01	-0.04	
AGE	Years (Avg.)	32.34	15.35	***	26.01	23.51	
Type of firms							
Independent (ORG 1)	Proportion	0.09	0.40	***	0.07	0.09	
Group: vertically integrated (ORG 2)	Proportion	0.12	0.13				
Group: vertically desintegrated (ORG 3)	Proportion	0.79	0.46	***	0.93	0.91	
Foreign firms (OWN)	Proportion	0.13	0.27	**	0.03	0.02	
Exports over sales (EXPORT)	Avg. %	47.36	80.79	***	30.91	36.22	
Employees (FSIZE)	Avg.	38.67	80.33	***	8.88	4.76	
Knowledge diffusion in the cluster (OUT-CLOS) (2)	Avg.	7.65	14.49	***	6.44	7.05	
b) University level variables							
Number of PRO	Count		4			5	
Scientific Quality (UQUAL) (1)	Avg.	0.40	0.58	***	0.79	0.66	***
University Scale (USCALE)	Publications (Avg.)	34.20	40.48	**	121.90	95.93	
Geographical Distance (GEOD)	Km (Avg.)	174.07	169.60	**	200.60	146.84	**

(1) Measured on the basis of all possible connections that could have been formed between the population of cluster firms and the universities included in the study. That makes 128 (i.e. 32 times 4) in Chile and 205 (41 times 5) in Italy.

(2) See methodology for definition.

*** Difference is significant at 1%, ** Difference is significant at 5%,* Difference is significant at 10%

4.2. Results of econometric estimations

Table 4 presents Equations 1 (U-I Selection) and 2 (U-I Diffusion) jointly estimated in a two-stage Heckman model for each country. The diagnosis statistics in the last rows show that the model is overall significant.[17] Regarding Equation 1, the econometric analysis is in line with the results in Table 3: while in Chile firms with stronger knowledge bases (*KB)* connect more to universities, in Italy they do not. In this latter case, firm *KB* is not a significant variable to explain the probability of the formation of an U-I linkage. Therefore, Hypothesis 1 is validated in the case of Chile, but it is rejected in the case of Italy. Hypothesis 2, which proposes a negative relation between university's scientific quality and the likelihood of forming U-I linkages, is supported for Italy and rejected for Chile. In fact, in Chile, universities with higher scientific quality are more connected to the industry, while the opposite relationships holds for Italy. Regarding Equation 2 (U-I Diffusion), we find consistently for both clusters that firms with stronger *KB* have higher *OUT-CLOS*. This supports Hypothesis 3 in both clusters: the strongest the firm knowledge bases, the higher their diffusion of knowledge to other cluster firms, and therefore, the higher the chances to diffuse university generated knowledge.[18]

Among the control variables, it is interesting that both firms' size and the scale of university proxied by the quantity of ISI papers are significant factors affecting the creation of U-I links in Chile, but not in Italy (Equation1). Results regarding *GEOD* are different to those expected from the literature. We found in Table 4 that while in Italy *GEOD* is not significant, in Chile it is significant but shows a positive sing: more distant universities seem to increase the probability of connecting to the industry. Two factors explain this apparently anomalous result. Firstly, as said above, the inclusion of universities in the sample is biased towards those that have at least one single connection. Thus, we cannot capture the real influence of geography. Secondly, *GEOD* is highly correlated with *UQUAL* in both clusters[19]. If *UQUAL* was excluded, *GEOD* would turned out significant and with negative sign. Although we acknowledge these shortfalls, we

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[17] The correlation of residuals in the first and second step (ρ), is not significant. This means that although correct, the Heckman model was not necessary. We could have estimated a Probit and an OLS models separately since our estimates are affected by selectivity only to a limited extent. Nevertheless, since the Heckman model is correctly specified and still corrects the small selectivity bias, we adopt a conservative attitude and prefer it against the alternatives.

[18] We also tested for the squared effect of *KB* but did not find significant results.

[19] Person correlation: -0.68 in Chile and +0.68 in Italy

decided to retain *GEOD* as a key control variable. In any case, the conclusions on our hypotheses remain unchanged whatever we decide to retain *GEOD* or not. Finally, among the control variables used in the U-I Diffusion (Eq. 2), foreign firms and firms that export more diffuse more knowledge to the rest of the firms in the cluster.

Table 4: Econometric results

	Heckman two-stage model			
	Chile		**Italia**	
	U-I Selection (Eq. 1)	U-I Diffusion (Eq. 2)	U-I Selection (Eq. 1)	U-I Diffusion (Eq. 2)
KB	0.486** [0.203]	3.138*** [0.652]	0.115 [0.145]	2.777*** [1.014]
UQUAL	6.827*** [1.341]		-3.364*** [1.217]	
USCALE	0.220*** [0.078]		0.003* [0.002]	
GEOD	0.391*** [0.131]		0.001 [0.002]	
FSIZE	0.008*** [0.003]	-0.005 [0.005]	-0.030** [0.013]	-0.056 [0.204]
AGE	-0.015*** [0.005]	-0.009 [0.046]	0.002 [0.004]	0.032 [0.027]
ORG2	-0.487 [0.561]	11.299*** [2.079]		
ORG3	-1.304** [0.517]	5.096*** [1.435]	-0.2 [0.411]	0.079 [2.838]
OWN	0.075 [0.444]	4.602*** [1.367]	-0.102 [0.587]	11.026*** [1.954]
EXPORTS		0.111*** [0.019]		0.083* [0.045]
Constant Term	-78.181*** [25.986]	-0.967 [2.458]	1.460** [0.671]	4.11 [6.233]
Observations	128		205	
Censored	76		160	
Uncensored	52		45	
LL	-178.59***		-229.56***	
Wald c^2	88.04***			
r (p-value)	0.17 (0.49)		-0.14 (0.84)	
Overall correct selection	83%		79%	

*** Significant at 1%, ** Significant at 5%,* Significant at 10%

4.3 Robustness checks

In order to enhance the robustness of these results, in Table I (Appendix II), we present two different specifications of Equations 1 and 2, in the attempt to cover different dimensions of the firm knowledge bases. The reader will recall that firm *KB* is a composite indicator of three firms' characteristics: formal training by human resources (*HR*), experience of skilled human resources (*MONTHS*), and experimentation (*EXPE*). In order to confirm that our composite indicator really accounts for firms' knowledge bases, our attempt in this robustness check consists in estimating two-stage Heckman models using the components rather than the composite *KB* indicator. Since the three elements are highly correlated (see Table 1-a), issues of multicolinearity must be taken into account. Therefore we include them separately. Under 'A' of Table I, we use another indicator of skills[20] as explanatory variable, whereas under 'B' we estimate the model using alternative indicators of experimentation.[21]

Results are consistent with those described for Table 4. Table I –A (Appendix II) shows that, in Chile, firms with more skilled workforce connect to universities more and they are more likely to diffuse knowledge to other cluster firms, whereas in Italy firms with more skilled workforce are also more likely to diffuse knowledge to other cluster firms, but do not generally connect to universities. In addition, results Table I-B (Appendix II) show that, in Chile, firms with high degree of experimentation have higher probability of connecting to universities than firms that do not experiment or experiment little, whereas in Italy, it is firms with low experimentation that are more likely to connect to the universities. Finally, consistent with Table 4 and the results above, we find that experimentation positively affect the degree to which firms diffuse knowledge to other cluster firms.[22]

[20] This variable is the score of principal component on *MONTHS* and *HR*, our two indicators of skills of the workforce.
[21] We include two dichotomous variables of low -*EXPE*= (1 or 2)- and high experimentation -*EXPE* = (3 or 4)-, with the base line being no experimentation –*EXPE*=0.
[22] In Italy only when *EXPE* is *high* (but not when it is *low*) firms show higher *OUT-CLOS* than firms with no experimentation (the baseline, *EXPE*=0). In contrast, in Chile, both firms with *low* and *high EXPE* have higher *OUT-CLOS* than firms with no experimentation.

5 Conclusions

This paper contributes to the debate on whether or not University-Industry linkages should be promoted for enhancing innovation and development. In particular, we acknowledge the existence of a debate about the beneficial effects of U-I linkages and propose an alternative and novel viewpoint on the subject. We suggest that *some* U-I linkages are bound to be more 'valuable' than others, based on the different potential for knowledge diffusion of firms that establish U-I linkages. Thus, we frame a research question to explore what are the factors that influence the formation of 'valuable' U-I linkages. Based on an original dataset of wine producers in two wine regional clusters, in Chile and Italy, we apply a Heckman two-stage selection model, to estimate, first, the probability of forming U-I linkage and, second, the potential for knowledge diffusion of any formed linkage in a regional cluster. The results are very interesting and somewhat unexpected.

In Chile, we find that the probability of forming U-I linkages rises if firms have stronger knowledge bases and universities have higher scientific quality. Also, firms with stronger knowledge bases have a higher potential to diffuse knowledge to other wine producers in the regional cluster. In the Italian case the results are strikingly different. We find that the formation of U-I linkages is higher for universities with lower scientific quality, whereas the knowledge base of the firms is not a significant player in the formation of U-I linkages. This means that lower quality universities form linkages with firms irrespective to the strength of their knowledge bases. At the same time, we find that, as in the Chilean case, among the wine producers that form linkages with the university, it is only those with stronger knowledge bases that diffuse knowledge to other firms in the regional cluster. This suggests that, in Italy, a number of linkages are formed by the universities with firms that are 'dead-ends' in the knowledge pipeline – as in the case of firms with weak knowledge bases that tap into university knowledge but do not transfer knowledge to other firms in their regional cluster.

Hence, these results seem to reflect two different patterns of U-I linkage formation. In Chile, linkages are formed somewhat more "selectively", as the "best" firms tend to connect to the "best" universities and give rise to 'valuable' U-I linkages. In Italy, in contrast, U-I linkages are formed more "pervasively" by universities and the industry, irrespective of their internal qualities, with the result that they lead to the formation of many more '*un*valuable' U-I linkages – as e.g. in the case of linkages with 'dead-end' firms.

These findings are important for conceptual and policy-making reasons. In terms of conceptual advancement, this paper is original as it proposes a new perspective in the U-I linkages' literature, suggesting that research agendas should pay more attention at the factors that drives the formation of 'valuable' linkages, rather than at U-I linkages *per se*. In terms of the drivers of U-I linkages, we find contrasting results about the impact of the quality of universities on the formation of U-I linkages. In line with some of the results of Mansfield and Lee (1996), we find that Chilean universities with better scientific records have more linkages to the industry, whereas in Italy the opposite holds, consistent with D'Este and Patell (2007). Similar ambivalent results are found for the strength of firms' knowledge bases, which appears to be important in Chile but not in Italy in fostering the formation of U-I linkages. However, if we look at what could be associated with the formation of 'valuable' U-I linkages, results appear to be far less inconclusive. They seem to suggest that valuable linkages are more likely to be formed in contexts where U-I linkages are established more intensively by high quality universities *and* by firms with stronger knowledge bases – such as in our Chilean case.

As concerns policy-making, we believe that this paper prompts interesting speculations for thinking. First, it offers the opportunity to look at Latin American countries in a less rhetorical and pessimistic way, than is normally found in the literature. Even if, among European countries, Italy is by no means a shining example to be compared with, this study finds that the Chilean model of "selective" linkage formation seems to be more reasonable and justifiable from a policy-perspective, than the "pervasive" model found in the Italian case. Although we do not have direct evidence to establish the claim, in Chile, this model might have been the result of some of the policies that the government has adopted since the 1990s with respect to university-industry linkages. We refer here to Chile's competitive bidding schemes to finance innovative projects and new research ventures of firms and universities that decide to collaborate in strategic industries (such e.g. in the *Programas de Fomento* (PROFO) promoted by the national agency for industrial development

CORFO).[23] Given the fact that the allocation of funds is typically based on the quality of applicants and on the potential economic impacts of the proposed project (Echevarria, *et al.*, 1996), these schemes might have instilled in the country a competitive mentality that stimulates the best actors to gather together.[24]

Such a mentality is widely absent in Italy, where selection is often not based on meritocracy or on the quality of actors (Margottini, 2008). Also, the absence of a systematic and fully-fledged funding scheme to connect universities with the industry in agriculture, and in the wine industry in particular, might be responsible for the formation of many informal ties between universities and 'dead-end' firms. In fact, anecdotal evidence suggests that ties are often driven by the need of universities to find fields or vineyards where experimentations could be carried out, or, in other cases, by the need of wine producers with scarce internal skills to access "free" advice on specific matters.

On the basis of these speculations, our best policy recommendation here is that the promotion of U-I linkages should be selective, and that the selection should be based on factors that enhance knowledge diffusion at the regional or national level. Hence, ideally, it would be desirable that "good" universities link to a restricted number of "good" firms, that have sufficiently strong internal knowledge bases as to be able to absorb, to improve upon university-generated knowledge and to diffuse it to other firms in the economy (Cohen and Levinthal, 1990). In this way, university researchers should not be bothered with establishing a myriad of linkages with dead-end firms, and would also have time to concentrate on what their job is about – i.e. improving their research skills, generating public knowledge and maintaining autonomy in their research agendas. Following the same line of reasoning, and going into a more speculative terrain, we believe that, at least in developing countries, "weaker" universities should be supported to improve their internal scientific qualities, rather than being pushed to become problem-solvers for the industry.

[23] Given the centrality of natural resources in the Chilean development strategy, these funding schemes have targeted agriculture apart from manufacturing in general, and they have been extensively used also in the wine industry.
[24] Although developed with the objective of overcoming growth constraints of small firms (Benavente and Crespi, 2003), anecdotal evidence suggests that competitive bidding schemes have historically led to the selection of the best candidates among universities and the industry, both because these may be part of oligarchic elites with higher lobbying power and also because weakest actors do often lack the resources for sustaining the administrative load of the application.

This paper was set within specific empirical and methodological limits. The first is that this is a single industry study. The generalisation of its results is therefore bounded by the specificities of the wine industry. However, we consider the wine industry to be a suitable context in which to explore our research question for the importance played by university research in promoting technological change in the industry, as widely documented by the literature. The second limitation is about the fact that we have used a narrow definition of U-I linkages, considering only collaborative research and technical knowledge transfer between universities and firms. Similarly, we have operationalised the concept 'valuable' U-I linkages, focusing merely on their potential to diffuse knowledge to other firms in the regional clusters. This was driven by the availability of a unique dataset mapping inter-firm knowledge linkages at a cluster level (for a discussion on the limitations of these data see Giuliani, 2007a), and other scholars might want to develop other alternative measures of 'valuable' U-I linkages. The third limitation is about the lack of some control variables among university's characteristics, which should be taken seriously when interpreting the results. In particular, we did not control for the financing strategy of universities, as universities that rely on industry as main source of funding may be more open to U-I linkages, than universities fully financed by the Government. However, this concern is mitigated by the fact that, while there are some differences across the two countries, there is not significant variability between different universities within the same country, so that it is plausible that this variable would not affect the results substantially. However, further studies might also want to consider more or new university-related variables.

Last but not least, one further limitation is about the lack of an analysis of the performance or growth of the two clusters. This issue was beyond the scope of this paper, but it raises interesting questions for further research and thinking. We know that the two clusters have grown quite dynamically since the end of the 1980s, and it would be useful explore the consequences of the observed different patterns of U-I linkage formation in the longer term. On the one hand, one interesting question would be whether the "selective" process of U-I linkage formation leads to faster growth rates in the overall performance of cluster firms than the "pervasive" model. On the other hand, a question could be whether the "selective" model enhances skewness in the distribution of firms performance (i.e. those connected to the universities grow faster than the rest) more than the "pervasive" model. These are very intriguing questions and we leave them open for future research.

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Appendix I: List of University's Departments and other public research organisations

1. Chile

a. University of Talca: Facultad Ciencias Agrarias (Dep. Horticultura, Dep. Produccion Agricola y Centros Tecnologicos), Instituto de Biología Vegetal y Biotecnología.
b. University of Chile (Santiago): Facultad Ciencias agronòmicas (Dep. industria y enologia, Dep. de ingenieria y suelos, Dep. de recursos, Dep. de sanidad vegetal, Dep. de producción agricola).
c. Catholic University (Santiago): Facultad Ciencias agronòmicas y Facultad Ciencias Biologicas (Dep. de sanidad vegetal, Dep. de producción agricola; Dep. de ciencias vegetales, Dep. de fruticultura & enologia, dep. Dep. chem & bioproc engn; Dep. Ecologia, Dep. de omol & enol, Dep. de ciencias forestales).
d. INIA (Santiago): -

2. Italy

a. University of Pisa: Facoltà di Agraria (Dip. di Coltivazione e Difesa delle Specie Legnose, Dip. di Agronomia e Gestione dell'Agroecosistema, Dip. di Biologia delle Piante Agrarie, Dip. di Chimica e Biotecnologie Agrarie).
b. University of Florence: Facoltà di Agraria (Dip. interfacoltà di biologia vegetale, Laboratori di botanica agraria e forestale, Dip. di ingegneria agraria e forestale, Dip. di ortoflorofrutticoltura, Dip. di scienze del suolo e nutrizione della pianta, Dip. di scienze agronomiche e gestione del territorio agroforestale, Dip. di biotecnologie agrarie, Dip. di scienze e tecnologie ambientali forestali.)
c. University of Milan: Facoltà di Agraria (Consorzio A&Q, Istituto di idraulica agraria, Istituto di ingegneria agraria, Istituto di patologia vegetale, Dip. di produzione vegetale, Dip. di scienze biomolecolari e biotecnologie, Dip. di scienze e tecnologie alimentari e microbiologiche, Dip. di scienze molecolari agroalimentari)
d. Agenzia Regionale per lo Sviluppo e l'Innovazione del settore Agricolo e Forestale (ARSIA).
e. Research Institute of Conegliano Veneto.

Appendix II: Robustness checks

Table I: Econometric results on different model specifications

	A) Heckman two-stage model (using Skills)				B) Heckman two-stage model (using EXPE)			
	Chile		Italia		Chile		Italia	
	U-I Selection (Eq. 1)	U-I Diffusion (Eq. 2)	U-I Selection (Eq. 1)	U-I Diffusion (Eq. 2)	U-I Selection (Eq. 1)	U-I Diffusion (Eq. 2)	U-I Selection (Eq. 1)	U-I Diffusion (Eq. 2)
Skills (PC per cluster of *HR* and MONTHS)	0.318* [0.192]	3.526*** [0.502]	0.006 [0.155]	2.296** [1.159]				
Low EXPE (Dummy): values 1 / 2 of EXPE					0.682 [0.433]	11.633*** [2.374]	0.683*** [0.251]	2.618 [1.786]
High EXPE (Dummy): values 4 / 5 of EXPE					1.803*** [0.530]	9.043*** [2.606]	0.115 [0.487]	8.728*** [3.130]
GEOD	0.380*** [0.133]		0.002 [0.002]		0.433*** [0.127]		0.001 [0.002]	
UQUAL	6.646*** [1.365]		-3.446*** [1.086]		7.305*** [1.295]		-3.428*** [1.292]	
FSIZE	0.009*** [0.003]	-0.010*** [0.004]	-0.024** [0.011]	-0.041 [0.215]	0.009*** [0.003]	0.023*** [0.006]	-0.031** [0.016]	-0.3 [0.243]
USCALE	0.213*** [0.079]		0.003* [0.002]		0.247*** [0.075]		0.003** [0.002]	
AGE	-0.017*** [0.005]	0.017 [0.037]	0.002 [0.004]	0.026 [0.025]	-0.018*** [0.005]	0.001 [0.038]	0.004 [0.004]	0.047 [0.040]
ORG2	-0.388 [0.550]	12.643*** [1.544]			-1.016* [0.559]	9.847*** [2.419]		
ORG3	-1.410*** [0.516]	5.126*** [0.972]	-0.322 [0.401]	-0.916 [3.151]	-1.247** [0.535]	3.771*** [1.358]	-0.514 [0.555]	0.212 [3.687]
OWN	0.061 [0.449]	4.740*** [0.983]	-0.099 [0.588]	10.905*** [2.032]	-0.222 [0.460]	6.538*** [1.598]	0.21 [0.601]	12.626*** [2.185]
EXPORTS		0.118*** [0.017]		0.099** [0.042]		0.033 [0.025]		0.071 [0.048]
Constant Term	-75.916*** [26.305]	-1.471 [1.729]	1.544** [0.629]	3.028 [6.494]	-87.347*** [25.205]	-5.503** [2.377]	1.482* [0.815]	4.831 [7.567]
Observations	128		205		128		205	
Censored	76		160		76		160	
Uncensored	52		45		52		45	
LL	-171.14***		-230.77***		-176.29***		-225.29***	
Wald c^2	158.888***				228.93***			
r (p-value)	0.09 (0.65)		0.14 (0.84)		0.61 (0.04)		-0.48 (0.48)	
Overall correct selection	80%		79%		83%		77%	

*** Significant at 1%, ** Significant at 5%,* Significant at 10%

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