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Who are the researchers that are collaborating with industry? An analysis of the wine sectors in Chile, South Africa and Italy

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ABSTRACT

Research on University–industry (U-I) linkages and their determinants has increased significantly in the past few years. However, there is still controversy on the key factors explaining the formation of U-I linkages, and especially related to individual researcher characteristics. This paper provides new empirical evidence and, in particular, looks at the importance of researchers' individual characteristics and their institutional environments in explaining the propensity to engage in different types of U-I linkages. Based on an original dataset, we present new evidence on three wine producing areas – Piedmont, a region of Italy, Chile and South Africa – that have successfully responded to recent structural changes in the industry worldwide. Empirical findings reveal that researchers' individual characteristics, such as centrality in the academic system, age and sex, matter more than publishing records or formal degrees. Institutional specificities at country level also play a role in shaping the propensity of researchers to engage with industry.

1. Introduction

University–industry linkages (U-I) are not a new phenomenon, although their number and importance have been increasing (Etzkowitz, 1998). This may be due to the increased transdisciplinarity of the knowledge production process which is requiring tight and continuous interaction between science and technology (Faulkner, 1994), and to policies in the US and Europe – and increasingly in developing countries – aimed at promoting interaction between research organizations and industry (Geuna, 2001; Mowery et al., 2001; Velho and Saenz, 2002; van Looy et al., 2003).

All this has promoted growing interest in U-I interactions, which are usually investigated from the perspectives of the firm or the university involved. In the past, studies have focused on patenting, licensing and spin-offs, but these represent only a small fraction of possible U-I collaborations (Cohen et al., 2002). Several authors (Bonaccorsi and Piccaluga, 1994; D'Este and Fontana, 2007; Mora Valentin, 2002; Schartinger et al., 2002) highlight the many other types of links between universities and firms, ranging from informal meetings to researchers' involvement in industry commissioned consultancy, to joint research programmes, to the purchase of industry prototypes.

Since the late 1990s, the literature on U-I linkages is focused on the existence and drivers of U-I linkages and demonstrates that a variety of factors needs to be taken into account to explain U-I linkages, e.g. organizational characteristics, history and tradition (e.g. Bercovitz et al., 2001; O'Shea et al., 2005; Boardman, 2009) and researchers' individual attributes (e.g. Blumenthal et al., 1996; D'Este and Fontana, 2007; D'Este and Patel, 2007; Landry et al., 2007; Bekkers and Freitas Bodas, 2008; Bercovitz and Feldman, 2008; Van Rijnsoever et al., 2008; Boardman and Ponomariov, 2009). However, there is little consensus so far on what factors mediate the formation of U-I linkages.

This study aims to contribute by taking the researcher as the unit of analysis and providing new original evidence to assess the importance of two sets of factors on the propensity to engage in U-I linkages: (a) researchers' individual features such as: gender, age, education and academic reputation; and (b) the characteristics of the researchers' organizational contexts such as the type of

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organization (university vs other research organizations), department size and peer effect, that is, the impact of the presence of colleagues with U-I linkages in the same department. An improved understanding of these individual mechanisms, complementary to those concerning organizations, is a key input for policy makers in charge of designing and implementing policies to enhance U-I collaborations.

The focus of the present study is on researchers specialized in wine-related disciplines. The wine industry recently has experienced a process of dramatic technological change and modernization, spurred by the results of applied research from universities and research institutes and increased interaction between researchers and the industry (Aylward, 2003; Giuliani and Arza, 2009; Morrison and Rabellotti, 2007). These changes are occurring worldwide, with new producing areas emerging in countries as diverse as Argentina, Australia, Chile and South Africa among others. We provide new evidence on three particular wine producing contexts – Piedmont in Italy, Chile and South Africa – that have responded successfully to the structural changes experienced in the industry worldwide. We exploit an original set of data collected by the authors through a questionnaire survey administered to researchers in these three wine systems, and conduct an econometric analysis to study the microeconomic determinants of U-I linkages.

The evidence reveals that individual researcher characteristics, such as centrality in the academic system, sex and age, matter, while academic status, publishing record and formal education degrees are not significantly related to the formation of U-I linkages. Working in a university rather than in another type of research organization, makes a positive difference, while other organization characteristics do not appear to influence the emergence of U-I linkages. Institutional specificities at country level also play a role in shaping the propensity of researchers to engage with industry.

The paper is organized as follows. Section 2 reviews the literature on U-I linkages and develops an original conceptual framework to explore the determinants of the formation of U-I linkages. Section 3 provides an overview of the wine industry generally, and of the three specific contexts in which the research was conducted, and explains the rationale for their choice. Section 4 presents the data and the method of analysis. Section 5 presents the empirical results and Section 6 concludes.

2. Factors influencing the formation of U-I linkages: a conceptual framework

Despite the increasing attention devoted to the determinants of U-I linkages, there is still little consensus on what explains the formation of such linkages. From a theoretical standpoint, at least two approaches can be identified: (i) the 'evolutionary' and 'resource-based view' approaches, which explain the formation of linkages on the basis of the skills and capabilities of collaborating actors, whether individual researchers (e.g. Van Rijnsoever et al., 2008) or organizations such as firms and universities (e.g. Santoro and Chakrabarti, 2002; Giuliani and Arza, 2009); (ii) the 'institutional' approach, which tends to explain the formation of linkages through the context in which they are embedded – i.e. the type of organization, the culture and the environment in which research is undertaken (e.g. Etzkowitz, 1998; Owen-Smith et al., 2002; Feldman and Desrochers, 2004). Some studies combine these approaches, showing that the theories are complementary in explaining the formation of linkages (see e.g. Boardman, 2009; D'Este and Patel, 2007). Although considerable progress has been made, there are no conclusive results on the key determinants of U-I linkages. As shown in the remainder of this section, there is a

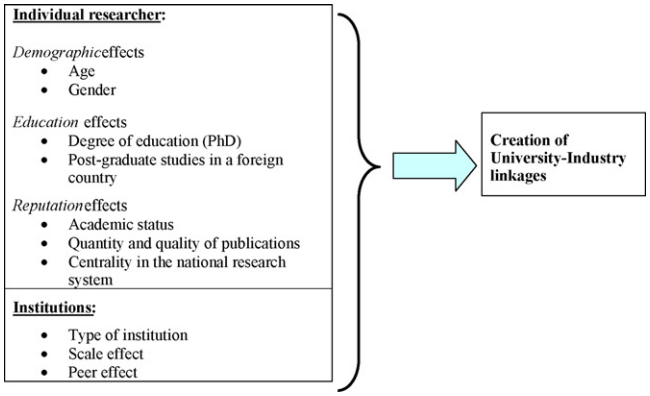

Fig. 1. Factors affecting the formation of U-I linkages.

bourgeoning literature on scientists' characteristics and their role in forging interactions with the industry (Blumenthal et al., 1996; Louis et al., 2001; D'Este and Fontana, 2007; D'Este and Patel, 2007; Landry et al., 2007; Bekkers and Freitas Bodas, 2008; Bercovitz and Feldman, 2008; Van Rijnsoever et al., 2008). In particular, Boardman and Ponomariov (2009) have proposed an exploratory assessment of the effects of a broad range of individual-level characteristics in a sample of US scientists, on their interactions with the private sector, emphasizing that there is substantial individual-level variation amongst university scientists, which influences whether and how they interact with industry.

Building on these studies, in this paper we provide new empirical evidence aimed at investigating the main factors influencing U-I linkages including in our analysis the characteristics of both individual researchers and their organizations. These factors, summarized in Fig. 1, are discussed in detail in Sections 2.1 and 2.2, with references to the existing literature, and some testable predictions are proposed for the later empirical analysis.

2.1. Individual researchers' characteristics

The literature identifies a number of factors influencing the probability of interactions between researchers and industry, the most important being: (i) researcher's *demographic* characteristics, i.e. age and gender; (ii) researcher's *education* characteristics, i.e. academic degree obtained; and (iii) researcher's *reputation* effects, related to academic status and scientific output.

2.2. Demographic effects

Debate over the impact of *age* on U-I linkages is inconclusive. On the one hand, some argue in favour of a greater involvement in U-I linkages of younger scholars, explained by the fact that they have been trained in an age of strong integration between universities and industry and by the fact that they may perceive interaction with industry as contributing positively to reputation (D'Este and Patel, 2007; Bercovitz and Feldman, 2008). On the other hand, younger scholars may feel greater pressure than established professors to publish, leaving the latter with more time to network with firms (Levin and Stephan, 1991). Boardman and Ponomariov (2009) find that older scientists are more likely to have worked with industry personnel on patents, and to have co-authored papers based on their greater accumulation of credentials and experience which may be relevant for these activities. At the same time, they find that younger scholars are more likely to have been approached by private companies with requests for information. Given this evidence, a curvilinear (U-shaped) relationship between age and U-I linkages can be envisaged, with the youngest and the

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oldest scholars interacting more with industry than scholars in the middle of their research careers.

With regard to the *sex* of the researcher, a few studies test the relationship between this variable and U-I linkages. Gulbrandsen and Smeby (2005) and Van Rijnsoever et al. (2008) include sex as a control variable in studying academic researchers' engagement with industry and do not find any significant gender differences. In contrast, Boardman and Ponomariov (2009) and Buttel and Goldberger (2002) find that male researchers have significantly more ties with industry, but only in certain types of U-I collaborations (e.g. as formal, paid consultants working on the commercialization of research with industry personnel; obtaining funding for joint research projects). Given that the available empirical evidence on gender effects does not provide clear-cut results, we leave this prediction open in our empirical model.

2.3. Education effects

The level of education – i.e. the highest formal degree achieved by the researcher (e.g. Masters or PhD) – represents the researcher's cognitive background and, therefore, may influence the attitude to and opportunity for links with industry (Klofsten and Jones-Evans, 2000). Again, there are no clear-cut empirical results in the literature. Taking a resource-based perspective, it could be argued that scholars with a PhD are more capable and, thus, more likely to be able to raise research funding from industry, than scholars with lower level degrees, therefore producing a higher intensity of U-I networking. However, the opposite argument might hold: scholars with a PhD might be involved in more 'blue-sky' research and consequently be more interested in publishing in scientific journals than in networking with industry. In this case, scholars with lower levels of education – i.e. no doctoral degree – might be willing to dedicate more time to setting up linkages with firms. Again, we leave this question open to empirical testing.

Similarly, we cannot make any firm predictions about the link between networking with the industry and *post graduate studies in a foreign country*. On the one hand, scholars returning from a period of training abroad may be more willing to share their knowledge with the domestic industry as a way of contributing to their home country's scientific and economic development process. On the other hand, scholars trained abroad may be keen to maintain linkages with foreign institutions and firms, while eschewing almost entirely local connections.

2.4. Reputation effects

The reputation of an academic scholar is tied to academic position (or status), to the quantity and quality of her/his publications and to the centrality in the national research system. In terms of *academic status*, we argue that a higher position (i.e. full professor, associate professor or senior researcher) is associated with a higher number of U-I linkages than the positions of assistant professor, research assistant or junior researcher, since firms are likely to feel more confident about advice obtained from tenured professors and senior researchers. This view finds support in D'Este and Patel (2007) and D'Este and Fontana (2007), who use UK data to show that the status of professor significantly increases the likelihood of engaging with industry. Boardman and Ponomariov's (2009) results are similar: they find that US tenured scientists are more likely to engage in a range of U-I interactions. In slight contrast, Gulbrandsen and Smeby (2005), drawing on a survey conducted in Norway, find that being a professor increases the probability of patenting with private firms, but not of engaging in other types of collaboration (i.e. start ups, consultancy work, development of new products). In contrast, Van Rijnsoever et al. (2008), using data from a Dutch university, find that academic rank is not related to industry collaboration. Overall, the evidence from empirical studies on this issue do not converge. We thus explore this dimension further in this paper.

Researcher's reputation is also influenced by the *quantity and quality of publications*. The traditional argument is that researchers with a high publication record exhibit strong commitment in terms of time and orientation, to furthering their research, at the expense of knowledge transfer outside the academic community (Blumenthal et al., 1996). The literature points out that there may be a trade-off between publications and U-I linkages, because researchers who are more connected to and receive more funding from industry have to write more reports and, therefore, have less time available to devote to journal articles (Jensen and Thursby, 2001). Hence, as suggested by Landry et al. (2007), the greater the researcher's assets in terms of publications, the lower will be her/his U-I knowledge transfer activity. In other words, publication quantity and excellence are substitutes not complements for U-I linkages.

However, this view has been challenged: it has been shown that this trade-off does not always apply and that in some cases researchers with high numbers of publications also excel in other activities, such as patenting and commercializing their discoveries (Breschi et al., 2008; Zucker and Durby, 1996). Moreover, academic output measured by the quality and quantity of publications is a sign of the expertise and experience of the researcher and increases visibility and prestige. Therefore, firms may prefer to interact with professors with established scientific reputations rather than with researchers who scientifically are less well known. Another point against the idea of a trade-off between U-I linkages and high levels of scientific output is the high cost of research equipment: the provision of external funding by industry to acquire laboratory instruments and other infrastructure, facilitated by the existence of U-I linkages, can positively influence the scientific productivity of researchers (Gulbrandsen and Smeby, 2005). Hence, researchers who want to maintain their quality standards are more likely to seek external funding and to establish U-I linkages for that purpose. We explore this proposition in the paper.

Finally, reputation is also based on the *degree of 'centrality' of a researcher in the national research system*. Centrality refers to the number of the researcher's linkages with other researchers in the country (e.g. participation in research projects involving different national universities).[4] The only study to date that has tested this relationship is Van Rijnsoever et al. (2008), who find that Dutch researchers with many linkages with academics outside their own universities also engage in significant networking with industry. Their explanation is that the larger the academic network, the more knowledge the researcher accumulates and the more she/he will be able to engage in knowledge transfer to the industry. We argue also that academic centrality reflects researchers' power and prestige, as researchers involved in many research projects are able to mobilize more research resources. In addition, centrality is a proxy for the strength of the researcher's social connections with the academic community and may signal prominence in a particular area of specialization. Thus, we propose that the more central a researcher in her/his national research system, the more intense will be her/his connections with industry.

[4] Note that being central in the country's research system does not necessarily imply that the researcher has a high publication record—measured by international peer reviewed publications, but rather that he/she maintains numerous research relationships with colleagues.

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2.5. Characteristics of research organizations and institutions

As well as individual researcher characteristics, in our empirical model we consider a second group of explanatory variables related to the characteristics of the organization and the broader institutional context in which the researcher is based, and which can favour (or constrain) the incentives to interact with industry.

Different *types of organizations*, namely universities and other public institutes, can be expected to interact differently with industry depending on their mission (Boardman, 2009). Public research organizations are often more pragmatically oriented than universities to performing applied research. They are regarded as effective mechanisms for two-way communication with industry and are less prone to being seen as 'ivory towers' (Mazzoleni and Nelson, 2007). Nevertheless, linkages with industry can be promoted by the university mission to support regional development (Etzkowitz and Leyedesdorff, 2000) and/or by the presence of an effective technology transfer office. This is particularly common in the case of agriculture-related scientific fields, such as oenology or viticulture, the context of this study. This is because university departments often carry out applied research activities in the field (Mazzoleni and Nelson, 2007). We leave this question open for investigation.

With regard to *department*, one variable studied in the literature is *scale* of research resources, measured in terms of academic research personnel or research income, as a condition to attract industry interest. In a study on Austria in the 1990s, Schartinger et al. (2002) predict a U-shaped relationship between department size and extent of industry interactions, with medium-sized departments being disadvantaged relative to smaller and larger departments. However, it should be stressed that this result refers only to small departments specialized in narrowly demarcated scientific fields because they are more likely to have the prerequisites favouring interactions. On the UK, D'Este and Fontana (2007) found that departmental characteristics lose significance once individual researchers' characteristics are considered. Similarly, in another study on collaborative research in the UK, D'Este and Fontana (2007) find no evidence of a significant impact of department size on the probability to engage with industry. Overall, the existing evidence does not seem to provide robust support for the claim that department size influences the degree of collaboration with industry.

Next, we look at the peer effect—i.e. the effect related to the imitation of colleagues in the department working on wine-related disciplines, who have engaged in U-I linkages (Bercovitz and Feldman, 2008). The peer effect is essentially an imitation effect and is based on mimetic isomorphism theory, a constraining process that forces one unit in a population to resemble other units faced with the same set of environmental conditions (DiMaggio and Powell, 1983). Hence, we expect that the more numerous the U-I linkages of colleagues, the higher will be the propensity of other researchers in the same department to have U-I linkages.

Finally, for the institutional context, most empirical analyses are at national level and, therefore, do not capture how different national structures and incentive mechanisms shape the behaviour of researchers in terms of their collaboration with industry (Perkmann and Walsh, 2007). However, the small amounts of evidence available suggest that the institutional context greatly affects the way that universities engage with industry (Owen-Smith, 2005). For instance, academic systems facing with budgetary difficulties will be more open to commercial collaborations with companies. In our investigation we control for the institutional context by including country dummies.

In sum, thus far, the empirical evidence on the factors influencing U-I linkages based on the characteristics of individual researchers and their research organizations appears often controversial. This study aims to address and provide original empirical evidence on some of these issues.

3. Why the wine industry, and why these regions?

Applied scientific fields are generally considered more likely to facilitate the formation of U-I linkages than pure sciences; this applies to fields such as agronomy, engineering and life sciences more than physics and mathematics. In this paper, we focus on scientific research on wine related issues.

The wine industry has undergone major structural industrial and market changes, which have been accompanied by scientific and technological shifts. The most recent technological change and modernization phase in the wine sector, known for being a traditional, craft-based activity, was spurred by the results of applied research conducted in universities and research institutes, and by the increased level of interaction between researchers and the industry (Aylward, 2003; Giuliani and Arza, 2009; Morrison and Rabellotti, 2007). Codification of production technology, grape growing and wine making techniques has increased and has allowed countries formerly not wine producers, to 'catch up' and emerge as exporters of fine wines. For instance, starting in the mid 1980s, countries such as Australia, New Zealand, South Africa, Chile and Argentina became competitive in the international market, challenging 'old world' producers such as France, Italy and Spain (Anderson et al., 2003; Cusmano et al., 2009).

Historically, public research organizations have played a central role in this industry. For many years, organizations and researchers from the Old World, primarily France but also Italy, led scientific research in this field. However, the research has become increasingly international and several leading research centres in both viticulture and oenology have emerged around the world. Various authors (Aylward, 2003; Cusmano et al., 2009) have noted that the recent process of technological renovation has been spurred by the considerable investment in new producer regions, such as California, Australia, New Zealand, Chile and South Africa. In the 1980s, some of these countries began investing in what could be defined as 'a wine system of innovation' and institutions, such as the University of California at Davis and the Roseworthy College in Australia, have become key players in scientific research on wine related issues. In both old and new producing countries, the strengthening of these *wine systems of innovation* and particularly the interaction between researchers and industry have been identified as the key to competitiveness in the wine industry (Giuliani and Arza, 2009).

For all these reasons, an analysis of the factors influencing the formation of U-I linkages in the wine industry is interesting. Our study is based on data collected in three different contexts: two being significant examples of 'new world' producers – Chile and South Africa – and one an 'old' traditional producer—Italy.

3.1. Chile

Chile is considered a shining star among the so-called 'new world' producers, for wine production and export. Over the past 30 years, apart from a dip in the early 1990s, growth in Chilean production has been dramatic. Exports as a proportion of total production have risen more rapidly than in the other 'new world' countries, with nearly half of total production exported. This resulted in an extraordinary transformation in the structure of Chile's production and trade. However, it was not until the late 1990s that the quality of Chilean wine improved (Bell and Giuliani, 2007).

Chile's success is based on a process of technological renovation, which transformed an old market into a modern and dynamic, export-oriented industry—which now plays an important role in the country's economy. Significant investments to support innova-

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tion and scientific research were undertaken by both the industry and several Chilean institutions. In the past ten years, several wine producers – mostly large-sized – have collaborated with Chilean universities in research projects financed by the Chilean Industrial Promotion Board (*Corporación de Fomento*, CORFO) and the National S&T Council (CONICYT), through bidding schemes or competitive funding (Moguillansky et al., 2006).

There is an explicit policy objective of strengthening Chile's national wine research system through tight links between research organizations and the industry. In 2005, two large technological consortia were established, involving all the main wine producers' business associations and the main universities and wine related public research centres. There is a clear intention that these consortia should play a key role in managing research funding, selecting projects and promoting research to address very specific wine industry problems.

3.2. South Africa

The tradition of wine making in South Africa dates back to the 17th century. Since the end of Apartheid in 1994, the South African economy as well as its wine industry has undergone deep structural reforms. Previously, production quotas, import protection and price support were in place to prevent overproduction; moreover, regulation had the side effect of keeping prices high and distorting production towards high yields at the expense of quality. Deregulation forced a restructuring of the South African wine industry and a focus on quality rather than volume. Many producers have adapted to the international pattern of demand by planting noble international varieties and adopting advanced oenological and viticulture techniques. As a result, in the last ten years the South African wine industry has experienced a rapid boost in exports and, in 2006, was ranked 4th among the new world producers and 9th at world level (AWBC, 2009).

Notwithstanding these very positive results, both production and exports are still dominated by cheap wines, and the restructuring of the industry is not complete. In this respect South Africa differs quite significantly from new world producers such as Chile, which have been able to export remarkably high shares of their vintage and enter a fast growing market with their brands (Vink et al., 2004).

In order to respond to the challenges posed by global markets, and in an attempt to reduce the gap with other new world producers, the South African wine industry recently initiated a major process of institutional renewal. This led to the establishment of the South African Wine and Brandy Company (SAWB) in 2002 and, in 2006, to a broader consensus among industry stakeholders in particular to overcome the legacies of the apartheid regime and give proper representation to the interests of black workers and investors, in the creation of a new single representative industry body, the South African Wine Industry Council (SAWIC).

Within this new institutional framework, various technical and scientific organizations play strategic roles. The Wine Industry Network of Expertise and Technology (Winetech) has explicit responsibility for promoting and coordinating wine research, and is also the main funding body. Winetech's main partners are universities and national research institutions, in particular the Agriculture Research Council (ARC), and the University of Stellenbosch, which can be considered pillars of the South African wine research system, absorbing more than 90% of its research funding. Funding for wine research is competitive and projects focus on applied research aimed at industry needs. Winetech pays great attention to the dissemination of results to end-users and most of its projects explicitly require specific extension interventions (Lorentzen, 2009). Thus, the unique structure of the South African institutional framework makes this country a particularly interesting case for the study of U-I relationships.

3.3. Italy (Piedmont)

Italy is a traditional wine producing country and one the world's leading wine producers, ranked first for volume of exports and second after France for value, and accounted for 17% of world production in 2007 (AWBC, 2009). Within Italy, in this study we focus on Piedmont, which produces some of the best known Italian wines (e.g. Asti Spumante, Barolo, Barbera) and is the second largest (after Veneto) exporting region in Italy, with a share of about 23% of all Italian exports in 2008 (ISTAT, 2009).

Over the last 20 years, the Italian wine sector has undergone a deep restructuring, in reaction to changes in both the domestic and international markets. On the one hand, there has been a major decline in domestic demand and a shift in consumer preferences towards higher quality wines; on the other hand, there is increasing competition in the international market from new world wine producers. As a result, firms have been forced to modify their production strategies and focus on quality and cost efficient production processes. Overall the wine sector is performing reasonably well, and holding its own in the face of external competition and changes in consumption patterns.

Due to its strong specialization in high quality traditional wines for the international market, Piedmont provides a good case study for an investigation of the U-I linkages in the wine industry. At the regional level, there are a number of research institutions participating in research and development (R&D) projects in the field of oenology and viticulture, including public research organizations and universities. In addition, producers associations play a key role in disseminating technical knowledge and providing technical support to their members, especially *Vignaioli Piemontesi*, the largest association of wine and grape producers in Italy with more than 8000 members. *Vignaioli Piemontesi* employs a team of technicians, mainly agronomists, who work closely with member firms and – particularly for small firms – often take responsibility for the whole agronomic management of the vineyards. *Vignaioli Piemontesi* participates directly in local research projects in collaboration with university researchers, acting mainly as the technical partner for the scientific institutions involved in these projects. Morrison and Rabellotti (2007) shows that the wine innovation system in Piedmont is characterized by a core of R&D and extension organizations that play a central role in diffusing knowledge efficiently to a large number of firms.

4. Methodology

4.1. The data

The study is based on original survey data collected in Piedmont (Italy), Chile and South Africa in the period October 2005 to October 2006. The survey was carried out through personal interviews with researchers whose research agendas were based on wine-related issues, and spanning a number of disciplines (e.g. viticulture, oenology, agronomy, microbiology, genetics, chemistry, engineering). The populations of researchers with these characteristics were selected with the help of local experts and informants in the area. We interviewed 40 researchers in Chile, 42 in South Africa and 53 in Piedmont (Italy) (see Table 1 for affiliations of interviewees). The number of researchers involved in this study is relatively small. However, it should be noted, first, that the researchers interviewed represent the universe of active researchers in wine-related research fields in the three contexts examined; and second, that our dataset provides unique and origi-

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Table 1
Distribution of researchers according to institutional affiliation (%).

Chile		South Africa		Piedmont	
Universidad Católica (Santiago)	33%	Stellenbosch University	55%	Consiglio Nazionale delle Ricerche (CNR)	12%
Universidad de Chile (Santiago)	40%	Pretoria University	2%	Istituto Sperimentale per la Viticoltura	13%
Universidad de Santiago de Chile (USACH)	5%	Agricultural Research Council (ARC) Infruitec Nietvoorbij	41%	Istituto Sperimentale per l'Enologia	7%
Universidad de Talca	5%	Agricultural Research Council (ARC) Plant Protection	2%	Regione Piemonte	4%
Universidad de Concepción	3%			Azienda sperimentale "Tenuta Cannona"	4%
Universidad Federico Santa Maria	5%			Università Cattolica di Piacenza	18%
Centro de Informacion de Recursos Naturales (CIREN)	3%			Università di Milano	11%
Instituto Nacionoal Investigacion Agropecuaria (INIA)	5%			Università di Bologna	8%
				Università del Piemonte Orientale, Novara	4%
				Università di Torino	17%
				Institut Agricole Regional, Aosta	2%
Total No. of researchers	40		42		53

nal information on researchers' characteristics and firm–university interactions. These data are not usually available from secondary sources.

The questionnaire covers many aspects related to the researcher's background and her/his personal collaborations with other researchers and other people in the industry. This background information on researchers' personal profiles also includes information on education and work experience (e.g. age, sex, years of experience in research, position, affiliations, level of education). Relational data on collaborations were gathered via a specific section of the questionnaire, in a format suitable for social network analysis (Giuliani and Rabellotti, in press), through the *free recall* method. This consists of asking respondents to name the people with whom they collaborate, on a free recall basis, that is, without offering them a list of names from which to choose. This was the only viable way to collect these relational data since we did not have advance knowledge about the population of industry representatives, and did not want to limit the possibility of choosing academics out of the list of those active in wine-related disciplines (Wasserman and Faust, 1994). Specifically, we were interested in two types of relational data: (i) data on U-I linkages between the interviewee and professionals in the domestic industry; and (ii) data on academic linkages between the interviewee and other researchers in their own country and abroad. Respondents were asked to provide names and some main characteristics of the collaboration (specific issues about relational data collection are reported in Appendix A.1).

4.2. The variables

The aim of the analysis is to explore the relation between researchers' personal features and the characteristics of the researchers' organizations, and the likelihood of establishing linkages with industry. This econometric analysis estimates a Poisson model by pooling the data for the three areas studied. Given that data come from three different populations of researchers, the model controls for the possibility that random disturbances in the regression are correlated within groups. The control is needed because we can expect that researchers sharing an observable characteristic, such as location, may also share unobservable characteristics which could lead to spurious results when estimating the effects of aggregated variables on a single observation (Moulton, 1990). In what follows, we present the dependent and independent variables included in the model and our predictions about their behaviour.

4.3. Dependent variable: U-I link

The *dependent variable* (*U-I Link*) measures the number of linkages a researcher establishes with industry representatives (professionals, entrepreneurs, etc.), on the basis of the relational questions reported in Appendix. It is measured as the normalized degree of centrality (NDC) of each researcher's U-I network, which corresponds to the number of linkages formed by each researcher, normalized by the total number of linkages reported by researchers for each country (see Appendix A.2.1 for details on this variable).[5]

4.4. Independent variables

We include in the model independent variables for the characteristics of both researchers and their organizations and also country dummy variables. These are described below.

4.4.1. Individual researcher

4.4.1.1. Demographic variables. Age of researcher and age squared (*Agesq*) to test non-linear behaviour. Thus, we test a curvilinear (U-shaped) relationship between age and U-I linkages and expect that much younger and much older scholars have more linkages than scholars whose ages are between these extremes.

Sex is measured as a dummy variable (Male is 0; Female is 1), with an open prediction, given the absence of any previous clear empirical evidence on this matter.

4.4.1.2. Training variables. PhD measures researcher's education (i.e. PhD or not) with a dummy variable that takes the value 1 if the researcher has a PhD and 0 otherwise. Predictions vary on the basis of the empirical evidence, and therefore we leave them open.

Postgrad_abroad: takes the value 1 if the researcher's postgraduate studies were undertaken abroad, 0 otherwise. Again, predictions are open.

4.4.1.3. Reputation variables. Position: this variable indicates the status of the researcher. It takes the value 1 if the researcher has

[5] *U-I Link* is a discrete variable ranging from 0 to a maximum value of 3.70.

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Table 2
Descriptive statistics of dependent and independent variables in Chile, South Africa and Italy.

	Dep. Var.	Demographic		Training		Reputation				Institutions		
	U-I Link per researcher	*Age* avg.	*Sex* % male	*PhD* %	*Postgrad _abroad* (%)	*Position* (%)	*TNP*	*QTP*	*Acad_ centr*	*Sizedep* (avg. no. of researchers)	*Peer effect*	*Type_org* (% Universities)
Chile	4.42	48.2	82.5	68.0	60	55.0	6.63	4.4751	3.38	85.35	1.23	90%
Italy	2.66	46.5	77.8	28.0	3.7	46.0	5.11	4.6927	2.78	47.5	1.49	61%
South Africa	3.07	43.0	76.2	64.0	14	36.0	6.10	2.9260	4.46	18.35	6.96	57%
Bonferroni test	No sig.	No sign.					No sign	No sign	SA>IT	CH>IT>SA	SA> IT>CH	
KW-*T* test			No sign	Sign.	Sign.	No sign						Sign.

a Full Professor or Associate Professor position at a university or a Senior Researcher position in a research institute, and 0 otherwise. Our expectation is that higher academic position is associated with a higher number of U-I linkages.

Total Number of Publications (TNP): this variable is based on the number of the researcher's publications recorded in Thompson's Institute of Scientific Information (ISI) Science and Social Sciences Citation Indexes (SSSCI).[6] We obtained publication records by matching names of researchers with articles in the ISI database, for 1990–2007. We expect a positive relationship between U-I linkages and this variable.

Quality of Total Publications (*QTP*): as an indicator of quality, we consider the number of citations received by a researcher's publications, based on those recorded in the ISI-SSSCI, excluding self-citations. This variable is normalized by the number of ISI publications and the number of years since publication to control for the fact that older publications are more cited as an effect of time rather than quality. Again, we expect a positive relationship.

Acad_centr: this variable indicates the centrality of the researcher in the domestic academic network, measured as the number of research linkages established by a researcher with other scholars from her/his own country, based on the relational question on academic linkages, reported in Appendix A.2.2. This is measured as the normalized degree of centrality, as explained in the Appendix A. We expect a positive relationship with U-I linkages.

4.4.2. Organizational characteristics

Sizedep and *Sizedepsq*: test for a non-linear relationship between scale of the department, measured as the number of researchers in the department, and U-I linkages.

Peer effect for researcher *i* is measured as the sum of the U-I linkages of all the wine researchers in the department to which researcher *i* is affiliated, minus the number of U-I linkages formed by *i*. We expect a positive relationship with U-I linkages.

Type_org: this variable indicates the type of organization and takes the value 1 if it is a university and 0 for a different research organization. This prediction is open.

Finally, we include in the model dummy variables to control for country-level institutional specificities.

5. Empirical results

5.1. Descriptive statistics

In this section we provide a descriptive analysis of the researchers involved in U-I linkages and investigate commonalities and differences across Chile, South Africa and Italy (Table 2).

Table 3
Different types of linkages with the industry (No. and % on total linkages for each country).

	Italy	Chile	South Africa
(i) Joint research agreements	67 (47)	64 (36)	25 (19)
(ii) Contract research agreements	20 (14)	36 (20)	31 (24)
(iii) Consultancy work	14 (10)	31 (18)	24 (19)
(vi) Informal contacts	24 (17)	19 (11)	31 (24)
(v) Attendance at conferences	12 (8)	10 (6)	5 (4)
(vi) Participation in electronic networks	0 (0)	0 (0)	0 (0)
(vii) Setting up of spin-off companies	0 (0)	0 (0)	3 (2)
(viii) Training of company employees	1 (1)	11 (6)	6 (5)
(ix) Student internship in firms	6 (4)	6 (3)	4 (3)
Total links	144 (100)	177 (100)	129 (100)

First, we can see that on average Chilean researchers maintain slightly more links with industry than do South African or Italian ones, although this difference is not statistically significant. Among the independent variables, most are not significantly different across countries, with the exception of training. Here, there is a substantial difference in the share of Italian researchers with a PhD, which is much lower than for Chile and South Africa.[7] For Chile, post-graduate international education of researchers is significantly different from South Africa and Italy: 60% of Chilean researchers undertake post-graduate study periods abroad. Also, while the figures on numbers of publications (TNP) are relatively similar across countries, the quality of publications (QTP) is higher for Chile and Italy than for South Africa.

In terms of links with other national researchers, South African researchers, on average, have more linkages than Italian researchers, while differences with Chilean researchers are negligible. This is highlighted by the indicator for researcher centrality in the academic network (Table 2).

In terms of researchers' affiliations to different organizations, Chilean researchers are mainly based in universities, while in Italy and South Africa 40% of the researchers interviewed were based in research centres related to the Ministry of Agriculture (both Italy and South Africa) and the National Research Council (Italy) (Table 1). The scale of departments in terms of numbers of affiliated researchers also differs, and is larger for Chile than for Italy or South Africa. Finally, the peer effect – total number of U-I linkages formed by all the researchers, in each department – is higher for South Africa than for Italy or Chile.

Table 3 shows the different types of links among researchers and the industry for the three areas. In Italy and Chile, the most frequent type of association is joint research agreements, while in South Africa research contracted by industry and undertaken by

[6] 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 renders some major limitations to the study: we are potentially excluding relevant research outputs, such as books, patents, and publications in journals not listed in the ISI database.

[7] This is partly explained by the peculiar organization of the Italian university system that prevailed until recently. Before the 2001 reform, which introduced a system based on a 3-year first degree followed by a 2-year Masters degree and then a Doctorate, in Italy the first degree was four-years followed by a PhD, a system introduced in the 1980s.

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researchers, plus informal contacts, are the two most frequent types of relationships. Finally, Chilean and South African researchers are more heavily involved in consultancy than their Italian counterparts.

Table 4 reports statistics for the dependent variable (i.e. number of collaborations with industry) organized according to the dichotomous variables in our study (i.e. *Sex*, *PhD*, *Postgrad_abroad*, *Position* and *Type_org*).[8] We observe that female researchers show a higher, though not significant, propensity to link with the industry. Similarly, academic researchers with a PhD or with a higher professional status (i.e. full professor, associate professor, senior researcher), on average have more connections, but the differences are not statistically significant. The only statistically significant differences are related to researchers' organizational affiliations and their post-graduate study abroad. Academic researchers affiliated to a university rather than another type of research organization, and those whose post-graduate study was abroad, display higher propensities to make contacts with industry.

5.2. Econometric results

In this section we present the main results of the econometric exercise. Table 5 includes different specifications of the Poisson estimation based on the groups of variables identified in the literature as the main factors influencing U-I linkages.[9] Model 1 includes only demographic variables; Model 2 includes the training variables; Model 3 includes the reputation variables; and Model 4 includes the variables related to the characteristics of the organizations. All models control for country-level characteristics. The main results for each set of variables are presented below.

Among researchers' demographic characteristics, the variable *Age* is always statistically significant and negatively related to the number of a researcher's collaborations with industry, while *Agesq* is not significant, indicating that the expected U-shaped relationship is not present. This suggests that younger scholars are more likely than their older colleagues to form U-I linkages. Moreover, when controlling for age, women are more likely than their male colleagues to form linkages with the industry, as indicated by the positive and significant coefficient of the variable *Sex*.

None of the training variables – i.e. having a PhD and/or undertaking post graduate studies in a foreign country – is statistically significant.[10] Among reputation effects, centrality in the domestic academic network (*Acad_centr*) is significant and positive, but neither researcher status (*Position*) nor scientific excellence (number of publications *TNP* and average number of citations *QTP*) is significant. Among research organization characteristics, Model 4 suggests that the only significant variable is the dummy distinguishing between universities and other research centres (*Type_org*); it seems that university researchers enter into more U-I linkages than researchers from other types of research organizations. Neither size of department nor peer effect is significantly related to the formation of U-I linkages.[11]

Finally, the dummy control variables for Chile (*DCH*) and Italy (*DIT*) are both negatively and statistically significant in all the four models, which indicates that, when controlling for all the other variables, South African researchers are most likely to be engaged with industry.

5.3. Discussion of results

The key results emerging from the empirical analysis are as follows. First, in line with Van Rijnsoever et al. (2008), we find that the centrality of researchers in the national research system is highly significant. We included this variable among those signalling the reputation of a scholar. This centrality may reflect an active relational propensity, which in turn may boost the visibility of a scholar *vis-à-vis* the industry, via word of mouth or through formal or informal interactions. Also, it is plausible that more central scholars have higher chances of being informed about, and possibly being involved in, projects with industry than less central ones. This is particularly the case in the context of the wine innovation systems being investigated here, which are rather small, and involved a similarly relatively small number of researchers and firms. Thus, it is conceivable that the most central researchers in these innovation systems also enjoy the highest standing within the industry and that, for the industry, this reputational dimension is more prominent than other forms of reputation, such as researchers' publishing performance. Furthermore, it is reasonable that industry representatives are interested in connecting with the most central researchers, not just because they are prominent, but also because through them they might access larger communities of academics, which, in turn, might increase the opportunities to obtain novel information and establish further research collaborations.

Second, we find that researchers' demographic characteristics, such as age and sex, are related to the propensity for researchers to form U-I linkages, whereas educational background, academic status and publication performance do not seem to influence this relationship. There are two plausible explanations for this finding: first, education, status and publications are not perceived or are only valued superficially by professionals in the industry; and second, it is possible that professionals with higher academic degrees and higher scientific quality do not engage in very applied research projects aimed at solving practical matters relevant to industry.

The negative statistical significance of the variable *age* – and the non-significant U-shaped relationship – suggest that younger scholars are more likely to form U-I linkages compared with their older colleagues, a result that is in line with D'Este and Patel (2007) and Bercovitz and Feldman (2008). This confirms the existence of a new trend and mentality among younger scholars, who give prominence to industrial linkages.

An interesting and original finding is the higher propensity of women to establish linkages with the industry (as reflected by the positive and significant sign of the *sex* variable). As stated in Section 2, the existing literature finds either an opposite result - i.e. that male colleagues have more U-I linkages (as in Buttel and Goldberger, 2002; Boardman and Ponomariov, 2009) or the absence of a gender difference (as in Gulbrandsen and Smeby, 2005; Van Rijnsoever et al., 2008). Our result is also interesting in that the wine industry traditionally has been a male-dominated domain, although over time the presence of women has increased both in firms and other institutions (Matasar, 2006). Note however that sex becomes significant once we control for peer effect which is higher for women than for their male colleagues (see Table A.2

[8] Correlations between the dependent variable and continuous independent variables are available in the correlation matrix displayed in Table A.1.

[9] The estimator based on the Poisson likelihood function is consistent also for non integer data (see Santos Silva and Tenreyro, 2006).

[10] In Models 3 and 4 the variable *Postgrad_abroad* was dropped to avoid multicollinearity with the variable *PhD*. In fact, as shown in the correlation matrix (in the Appendix), these two variables have a positive and significant *phi* correlation coefficient (0.40). *Postgrad_abroad* was dropped because it is also correlated with other variables.

[11] It should be noted that *Type_org* absorbs the effect of *Peer effect*, which is significantly correlated with the dependent variable (see the correlation matrix in the Appendix). In fact, there is a strong relationship between *Type_org* and *Peer effect* (p-value for the ANOVA is 0.017), due to the fact that, in universities, the number of linkages to industry is generally higher than in other research organizations. This, in turn, implies that *Peer effect* is systematically higher in universities than in other organizations.

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Table 4
Descriptive statistics of the dependent variable.

Number of U-I links	Sex		PhD		Postgrad abroad		Position		Type_org	
	Male	Female	Yes	No	Yes	No	Prof[a]	Other	Univ.	Other
Average	3.2	3.8	3.5	3.2	4.5	3.0	3.8	3.1	3.8	2.4
Min	0	0	0	0	0	0	0	0	0	0
Max	30	10	30	13	30	13	11	30	30	10
t-test (95%confidence level)	No sign.		No sign.		Sign.		No sign.		Sign.	

[a] Full professor, Associate professor, Senior researcher.

Table 5
The Poisson estimation of the determinants of U-I linkages.

Variables	Model 1	Model 2	Model 3	Model 4
(a) Demographic variables				
Age	−0.0150194*** (0.00338)	−0.0150785*** (0.00417)	−0.0163543*** (0.00450)	−0.0108003* (0.00653)
Agesq0.	000013 (0.00059)	−0.000032 (.00066)	−0.0000171 (0.00076)	90.60e−06 (0.00079)
Sex	0.116046* (0.050272)	0.1116865* (0.06732)	0.1208809* (0.07006)	0.1192763 *** (0.03957)
(b) Training variables				
PhD		−0.1263165 (0.18785)	−0.1286381 (0.142067)	−0.2496669 (0.23186)
Postgrad_abroad		0.1496507 (0.34767)		
(c) Reputation variables				
Position			0.2625439 (0.23793)	0.1196949 (0.24513)
TNP			0.0108492 (0.00920)	0.0071591 (0.00700)
QTP			−0.0004341 (0.0044701)	−0.0053484 (0.00375)
Acad_centr			0.1228068*** (0.03173)	0.1053611** (0.04298)
(d)Characteristics of institutions				
Type_org				0.2008061 *** (0.04218)
Sizedep				−0.0035615 (0.00526)
Sizedepsq				0.000022 (0.00002)
Peer effect				0.0081867 (0.00698)
(e) Control variables				
DCH	−0.8374153*** (0.01509)	−0.8963006*** (0.12547)	−0.8325766*** (0.19019)	−0.6670667 ** (0.23424)
DIT	−0.7186895*** (0.01136)	−0.7465869*** (0.05900)	−0.5771265*** (0.19019)	−0.4967342*** (0.09737)
Constant	0.8315451 (0.19142)	−0.8958582 (0.24252)	−0.2582145 (0.35481)	0.1698557 (0.50804)
No. of observations	136	136	136	119
Log pseudo-L	−144.89205	−144.66386	−136.92549	−121.83999

The standard errors are reported in parentheses. Coefficients marked with ***, ** and * are significant at 0.01, 0.05 and 0.10 level respectively.

in the Appendix A), suggesting that their higher involvement in U-I linkages might be due to the fact that department colleagues are also significantly involved in U-I linkages.[12] This result suggests that the *organizational context* in which women work may moderate traditional differences vis à vis men – and indeed boost their relational abilities with the industry. This is consistent with Whittington and Smith-Doerr (2008), who studied the patenting behavior of US female scientists in life-sciences. They find that women employed in bio-tech firms, where the organization of innovation is network-based and based on collective work practices, have the same probability of patenting at least once as their male colleagues. In contrast, for more individualist and hierarchical environments, such as academia, the gap between women and men is still significant, with the former still suffering from significant job segregation. Whittington and Smith-Doerr (2008) conclude that the organizational context influences the likelihood of female scientists expressing their abilities and skills. In our case, a working environment that promotes U-I linkages, reflected by a high peer-effect, may act as a trigger and boost female researchers' capabilities to engage with industry. However, it is important to stress that the female scientists in our study have some outstanding qualities. The descriptive statistics reported in Table A.2 reveal that they have the same capacity for winning research projects as their male colleagues (as reflected by the indicator of academic centrality) despite being much younger (40 years on average vs. 47 for males) and with less academic experience (around 12 years vs. 20). Hence, it is plausible to conclude that the organizational context in which women work enhances and valorizes their outstanding individual skills and abilities to network with industry.

Third, working in a university vis-à-vis another type of public research organization produces a higher propensity to engage with industry but the characteristics of the research organizations where researchers work appear to influence U-I linkages to a lesser extent. This finding might indicate that firms prefer to link up with more prestigious actors, such as universities, rather than government institutions, which are often regarded as inefficient. On the other hand, it might show that in the specific scientific field under investigation, universities carry out applied research that is relevant for the industry and that the image of universities as ivory towers, does not seem pervasive in the wine industry. This is consistent with qualitative evidence collected during the fieldwork, which highlights intensive involvement of universities in the wine industry, often through links forged university alumni working in the industry as oenologists or agronomists (Cusmano et al., 2009). Also, this result should be read in light of the fact that, as explained in footnote 8, universities generate systematically higher peer effects than other research organizations. Hence, it is possible that within the university environment researchers with U-I linkages reach a critical mass that boosts the formation of more U-I linkages, while this does not happen in the case of other research organizations. Department size does not appear to affect the likelihood of U-I linkages, confirming the results of other studies (D'Este and Patel, 2007).

[12] The mediating role of *peer effect* on sex is confirmed by partial correlations.

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Finally, our results confirm that, controlling for all other factors, the South African wine innovation system facilitates strong U-I linkages. This can be explained by the organization of South Africa's institutional framework in the wine sector and, in particular, the establishment and mandate of Winetech to promote, coordinate and finance research for the wine industry, a unique characteristic among the three countries. Winetech coordinates the industry's research needs, conveys them to the research community, and selects which research projects to finance. The funds allocated by Winetech are the main source of finance for research on wine-related issues in South Africa.[13] This specificity of the institutional setting could be the justification for the strong orientation of the South African research system towards collaboration with the wine industry.

6. Conclusions

Academic research institutions have long served as significant external sources of scientific and technical knowledge for industrial firms. However, the intensity and variety of activities at the U-I interface is growing, and it is crucial to improve our understanding of which university researchers are interacting with firms. In this paper we develop an original and rich conceptual framework providing new empirical evidence that allows us to test the characteristics of individual researchers and their organizations in terms of how they influence collaboration with industry. Because the results of similar studies have been inconclusive, our empirical contribution should help to advance the research in this area. The most significant results are discussed below.

The researchers from all the regions/countries considered here are very active in collaborating with industry and we found that there are some individual characteristics that tend to promote U-I linkages. That is to say, the researchers with a higher number of links with industry appear to be young, female and central in their national academic research systems. The finding about the youth of the researchers engaging in U-I links is in line with some existing studies, confirming that the newer generations of young scholars are more oriented to the productive world. This may be due to their training: much of the current rhetoric in universities and from policy-making agencies stresses the importance of industry, and is probably absorbed by scholars during their research training and early careers. Also, young scholars may feel that such an orientation will be rewarding from a professional point of view. Hence, it is possible that the fluidity of the interactions between the academic and professional communities – once considered two separate worlds – will increase in the future. Some have expressed concern about whether this greater involvement with industry is at the expense of publishing; however, our results are not illuminating on this issue. Future studies should explore, in greater depth, the existence of a trade-off between quality of scientific publications and U-I linkages for the younger generations of academic scholars.

Our result on the role of women and U-I links is interesting and novel compared to prior research. We posit that a new wave of highly capable and motivated women is taking the leadership in establishing both academic and U-I linkages. However, in line with recent gender studies, we also find that this occurs only within certain organizational contexts—in our case within departments where U-I linkages are common among colleagues who might promote a culture of academic interaction with industry. Also, it is possible that the involvement of women with the industry is not just due to their accommodating to or taking advantage of the organizational context, but it depends on the existence of intra-department linkages with other researchers, who may involve women scientists in their own industry collaborations. We believe that this area is worthy of further research, especially qualitative investigation on the motivations and conditions that generate this higher involvement of women in U-I linkages.

We also found that researchers who are more central within the academic research system are also more connected to the industry. This result is interesting and has different types of implications. First, it is coherent with established network theories, which suggest that centrality in a network may facilitate access to valuable resources and may be a source of power (e.g. Ibarra, 1993). Our study shows that a position of centrality in one network conveys a power (here named reputation), which, in turn, influences the degree of centrality in other (i.e. U-I) networks. In our findings, what makes researchers central in U-I networks is an informally-derived power, rather than influence based on formal academic position or expertise (i.e. publications or education). This is an interesting result leading to a second implication: being central actors within academia and in the interface between academia and industry may contribute to reducing the distance between these two communities, and permit a richer flow of knowledge from and to the industry. This is because researchers involved in numerous research projects with colleagues in the same country are repositories of and have access to a variety of scientific experience (i.e. those of their direct contacts in the academia), which they can transfer to industry, and vice versa. Hence, it is possible that the irrelevance of formal position and expertise in the formation of U-I linkages is offset by the emergence of a spontaneous networking process.

Finally, this work shows that national level policies may have a significant impact on researchers' collaborations with industry, as reflected by the South African case. Although this is one of few studies that use cross-country data, we do not investigate the comparative institutional aspect in great depth, and believe that this is an area that deserves future investigation.

We should also point to some limitations of this paper. It is a single-industry study and hence the results may be specific to the wine industry. However, we believe that some of our findings could spark debate and be informative for other industry contexts, especially those that rely heavily on the results of applied science, as it is the case with the agro-food industry, which is particularly important in many developing countries. This is relevant due to the increasing weight of scientific and technological knowledge to achieving competitiveness in natural-resource based activities, which is making the interactions between academia and industry and their understanding for policy-making quite critical.

Another limitation of this study is that it does not differentiate among different types of U-I linkages, and especially between formal and informal linkages. Had we made this distinction, it would have reduced the overall number of U-I linkages and, given the limited number of our observations, would have undermined the feasibility of the econometric exercise. But we believe that differentiating across different types of linkages is a valuable direction for further research.

We can draw only tentative implications for policy from this study since we do not know whether the U-I linkages investigated here are valuable in terms of generating positive economic impacts on the local economies, on the firms and on the academics involved in these interactions. However, we believe that policies to encourage U-I linkages should take account of the role of young scholars and female scientists. In relation to the former, their high propensity to work with the industry may be proof that new policies to encourage U-I links are working and are impacting on the new generation of scientists. If this is so, policy-makers should try to ensure that young researchers' interactions with the industry are oriented

[13] Winetech is largely financed by an export levy that applies to all exporters. In 2006 the total income was approximately RAND17 m. (approximately US$ 2.5 million) 80% of which came from the levy. Other funds are provided directly by SAWIT (i.e. South African Wine Industry Trust) (Winetech, 2006).

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towards the promotion of joint research projects, which also should contribute positively to their scientific capabilities and outputs. Instead, if U-I interactions would divert the interest (and time) of younger generations from undertaking high quality research, this would not be a good outcome.

Our result on gender differences prompts speculation about the importance of policies to generate academic environments where female scientists are given opportunities to demonstrate their capabilities and skills to the full. Gender studies emphasise that women's involvement in scientific and technological discovery is beneficial not just for their academic careers but also for the society (Whittington and Smith-Doerr, 2008). And this may apply also to their involvement in U-I linkages, as women may have better relational abilities than men and offer different perspectives and expertise from those of their male colleagues. So their increasing involvement in major academic activities should be encouraged.

To conclude, our result about academic centrality as a driver of higher U-I linkages raises some questions about policy promotion of these central actors. On the one hand, if the actors involved are a few prominent scholars with already existing power and reputation within the academic research community, then their U-I activities will enable knowledge to be diffused from the academia to the industry (and vice versa). On the other hand, it raises questions about the vulnerability of academic and U-I networks, as these central researchers are those who keep these networks connected and should they exit (e.g. retire, die, leave the country or the sector), the whole innovation system could be severely disrupted.[14] Also, excessive concentration of power in a few hands and the polarization of relations might act to restrict rather than open up opportunities for knowledge diffusion and U-I collaborations. This may be a drawback particularly for small research systems, with only a very small number of central researchers.

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Appendix A.

A.1. Network data

Two types of relational data have been collected:

(i) U-I linkages between the researchers interviewed and professionals in the industry;
(ii) Academic linkages between the researchers interviewed and other researchers in their own countries.

A.1.1. U-I linkages

This information is collected from the responses to the following question:

> "Please indicate the name of professionals/researchers with whom you have interacted through at least one of the different activities listed below, in the past 5 years".

The activities listed are: (i) joint research agreements (research undertaken by both parties); (ii) contract research agreements (research commissioned by industry and undertaken only by the university researchers); (iii) consultancy work (commissioned by industry, not involving original research); (vi) informal contacts (technical advice not based on a market transaction); (v) attendance at conferences with industry and university participation; (vi) participation in electronic networks (e.g. mailing lists); (vii) setting up of spin-off companies; (viii) training of company employees (through enrolment on courses, or personnel exchanges); (ix) student internships in firms (Table A.1).

A.1.2. Academic linkages

This information is collected from the responses to the following question:

> "Please indicate the names and affiliations of the academic researchers with whom you carried out research in wine-related fields in the past 5 years"

Different sections of the questionnaire have asked for the names of researchers: (i) working in the same department and/or university; (ii) working in another university, but in the same country; and (iii) working abroad. Only information derived from (i) and (ii) is used for this study.

The above questions have enabled collection of relational data on all respondents. Due to the difficulty of setting boundaries to researchers' direct contacts, respondents are asked to provide answers for a maximum of 10 individuals – researchers or professionals, according to the question, in line with Marsden (2005). On the basis of these data, two types of networks are constructed: (i) the U-I network, reporting the existence of a linkage (through any of the 9 possible channels listed above) between the respondent and the wine industry professionals named; (ii) the academic network, reporting the existence of a research linkage between the respondent and other researchers in the country. These network data are pooled within matrices, each corresponding to the different relationships in the country where the research is conducted. These matrices are used to construct the dependent variable and one independent variable, described below in detail.

A.2. Operalization of network data

A.2.1. Dependent variable (U-I Link)

Based on the question at Point (*i*) of this Appendix, the dependent variable measures the number of direct linkages formed by the researcher interviewed and professionals in the wine industry. This is calculated as the Normalized Degree Centrality (NDC), i.e. as the sum of the linkages of researcher *i* with other *j* professionals in the wine industry (degree centrality, DC_i) and standardized by *g*, with *g* being the number of nodes in the network:

$$NDC_i = \frac{DC_i}{g-1}.$$

The normalization is needed to make the data from the three country contexts comparable.

The computation of this variable includes all researchers interviewed, including those that report no linkages with the industry.

A.2.2. Independent variable: Academic centrality (acad_centr)

This variable measures the number of research linkages established by a researcher with other scholars in her/his country, based on the question reported at Point A.1.(ii) of this Appendix. Also the academic network (*acad_centr*) is measured as the NDC.

[14] South Africa is an example: a former director of the Institute of Biotechnology at the University of Stellenbosch, moved to Australia to become Managing Director of the Australian Wine Research Institute.

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Table A.1
The correlation matrix.

	U-I link	Age	Agesq	Sex	PhD	Postgrad_abroad	Position	TNP	QTP	Acad_centr	Sizedep	Sizedepsq	Peer effect	Type_of organization
U-I link	1.000													
Age	−0.204 (**0.017**)	1.000												
Agesq	−0.014 (0.867)	0.146 (0.089)	1.000											
Sex	0.268	**0.002**	0.237	1.000										
PhD	(0.806)	(0.722)	(0.428)	0.062 (0.473)	1.000									
Postgrad_ Abroad	(0.543)	(0.248)	(0.659)	0.077 (0.368)	0.408 (**0.000**)	1.000								
Position	(0.316)	(**0.010**)	(0.523)	0.069 0.423	0.176 (**0.040**)	0.410 (**0.000**)	1.000							
TNP	0.060 (0.486)	0.103 (0.231)	0.020 (0.817)	(0.374)	(0.352)	(0.342)	(0.493)	1.000						
QTP	−0.036 (0.678)	0.129 (0.136)	−0.055 (0.523)	(0.268)	(0.322)	(**0.099**)	(0.564)	0.139 0.107	1.000					
Acad_centr	0.427 (**0.000**)	−0.089 (0.305)	0.054 (0.531)	(0.980)	(0.864)	(0.750)	(0.459)	−0.002 (0.978)	−0.005 (0.953)	1.000				
Sizedep	−0.258 (**0.005**)	0.098 (0.287)	0.046 (0.622)	(0.785)	0.630)	(**0.011**)	(**0.000**)	−0.104 (0.262)	0.062 (0,.503)	−0.166 (0.071)	1.000			
Sizedepsq	−0.040 (0.667)	0.108 (0.242)	0.016 (0.861)	(0.619)	(0.152)	(0.167)	(0.284)	−0.019 (0.834)	−0.015 (0.873)	−0.027 (0.770)	0.610 (**0.000**)	1.000		
Peer effect	0.347 (**0.000**)	−0.258 (**0.002**)	−0.014 (0.867)	(**0.008**)	(**0.081**)	(0.656)	(0.150)	−0.014 (0.867)	0.011 (0.867)	0.293 (**0.001**)	−0.284 (**0.002**)	−0.066 (0.479)	1.000	
Type_org	(0.340)	(0.547)	(0.626)	0.032 (0.781)	0.311 (**0.000**)	0.303 (**0.000**)	0.386 (**0.000**)	(**0.016**)	(**0.009**)	(0.846)	(**0.015**)	(0.300)	(**0.017**)	1.000

Note: Spearman correlations, *T*-test and Phi-correlations are reported in the table. In the case of *T*-test, only the *p*-values are presented (in parenthesis). Statistically significant correlations are indicated in bold.

Table A.2
Descriptive statistics of the dependent and independent variables by gender.

	Dep. Var.	Demographic		Training			Reputation				Institutions	
	Average U-I Link per researcher	Age avg.	Sex % male	Average years experience	PhD %	Post-grad abroad (%)	Position (%)	TNP	QTP	Academic centrality	Peer Effect	Type org. (% Universities)
Male	3.2	47.4	78.7	20.6	52.3	25.2	35.5%	6.2	7.7	3.4	2.4	69.1
Female	3.8	40.7	21.3	12.8	44.8	17.2	27.6%	4.4	3.7	3.4	5.4	65.5
t-test (95%confidence level)	No sign.	Sign.	–	Sign.				No sign.	No Sign.	No sign.	Sign.	
Pearson chi^2					No sign.	No sign.	No sign.					No sign.

References

Anderson, K., Norman, D., Wittwer, G., 2003. Globalisation of the World's Wine Markets. The World Economy 26 (5), 659–687.

AWBC, 2009. Wine facts, Australian Wine and Brandy Corporation.

Aylward, D.K., 2003. A documentary of innovation support among new world wine industries. Journal of Wine Research 14 (1), 31–43.

Bekkers, R.B., Freitas Bodas, I.M., 2008. Analysing knowledge transfer channels between universities and industry: to what degree do sectors also matter? Research Policy 37, 1837–1853.

Bell, M., Giuliani, E., 2007. Catching up in the global wine industry: innovation systems, cluster knowledge networks and firm-level capabilities in Italy and Chile. International Journal of Technology and Globalisation 3 (2/3), 197–223.

Bercovitz, J., Feldman, M., Feller, I., Burton, R., 2001. Organizational structure as a determinant of academic patent and licesing behaviour: an exploratory study of Duke, John Hopkins, and Pennsylvania State University, Journal of Technology Transfer 26, 21–35.

Bercovitz, J., Feldman, M., 2008. Academic entrepreneurs: organizational change at the individual level. Organization Science 19 (1), 69–89.

Blumenthal, D., Campbell, E.G., Causino, N., Seashore Louis, K., 1996. Participation of life-science faculty in research relationships with industry. The New England Journal of Medicine 335(23), 1734–1739.

Bonaccorsi, A., Piccaluga, A., 1994. A theoretical framework for the evaluation of university- industry relationships. R&D Management 24 (3), 229–247.

Boardman, P.G., 2009. Government centrality to university-industry interactions: University research centers and the university involvement of academic researchers. Research Policy 38, 1505–1516.

Boardman, P.G., Ponomariov, B.L., 2009. University researchers working with private companies. Technovation 29, 142–153.

Breschi S., Lissoni F., Montobbio F., 2008. University patenting and scientific productivity. A quantitative study of Italian academic inventors. European Management Review. Journal of European Academy of Management 5(2), 91–109.

Buttel, F.H., Goldberger, J.R., 2002. Gender and agricultural science: evidence from two surveys of land-grant scientists. Rural Sociology 67 (1), 24–45.

Cohen, W.M., Nelson, R.R., Walsh, J.P., 2002. Links and impacts: the influence of public research on industrial R&D. Management Science 48 (1), 1–23.

Cusmano, L., Morrison, A., Rabellotti, R., 2009. Catching up Trajectories in the Wine Sector: A comparative study of Chile, Italy and South Africa, American Association of Wine Economists, no. 34, March.

D'Este, P., Fontana, R., 2007. What drives the emergence of entrepreneurial academics? A study on collaborative research partnerships in the UK. Research Evaluation 16 (4), 257–270.

D'Este, P., Patel, P., 2007. University–Industry linkages in the UK: what are the factors underlying the variety of interactions with industry? Research Policy 36 (9), 1295–1313.

DiMaggio, P., Powell, W., 1983. The Iron Cage revisited: institutional isomorphism and collective rationality in organizational fields. American Sociological Review 48 (2), 147–160.

Etzkowitz, H., 1998. The norms of entrepreneurial science: cognitive effects of the new university-industry linkage. Research Policy 27, 823–833.

Etzkowitz, H., Leyedesdorff, L., 2000. The dynamics of innovation: from national systems and 'mode 2' to a triple helix of university-industries-governments relations. Research Policy 39, 109–123.

Faulkner, W., 1994. Conceptualizing knowledge used in innovation: A second look at the science-technology distinction and industrial innovation. Science, Technology, & Human Values 19 (4), 425–458.

Feldman, M.P., Desrochers, P., 2004. Truth for its own sake: academic culture and technology transfer at Johns Hopkins University, Minerva 42, 105–126.

Geuna, A., 2001. The changing rationale for European university research funding: are there negative unintended consequences? Journal of Economic Issues 35 (3), 607–632.

Giuliani, E., Arza, V., 2009. What drives the formation of 'valuable' university-industry linkages? Insights from the wine industry. Research Policy 38, 906–921.

Giuliani, E., Rabellotti, R. Academic and I-U networks in the wine industry: A comparative Analysis of Italy, Chile and South Africa. In: Giuliani E., Morrison A., Rabellotti R. (Eds.), The changing geography of wine production: how New World countries catch up with world leaders. The Role of Science and Innovation, Edward Elgar, Chelthenam, in press.

Gulbrandsen, M., Smeby, J.-C., 2005. Industry funding and university professors' research performance. Research Policy 34 (6), 932–950.

Ibarra, H., 1993. Network centrality, power, and innovation involvement: determinants of technical and administrative roles. Academy of Management Journal 36 (3), 471–501.

ISTAT, 2009. Datawarehouse commercio estero, Istituto di Statistica, Rome.

Jensen, R., Thursby, M., 2001. Patent licensing and the research university. NBER WP 10758.

Landry, R., Amara, N., Ouimet, M., 2007. Determinants of knowledge transfer: evidence from Canadian university researchers in natural sciences and engineering. Journal of Technology Transfer 32 (6), 561–592.

Levin, S., Stephan, P., 1991. Research productivity over the life cycle: evidence for academic scientists. The American Economic Review 81, 114–132.

van Looy, B., Debackere, K., Andries, P., 2003. Policies to stimulate regional innovation capabilities via university-industry collaboration: an analysis and an assessment. R&D Management 33 (2), 209–229.

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Lorentzen, J., 2009. The geography of innovation in South Africa: a first cut. International Journal of Technological Learning, Innovation, and Development 2 (3), 210–229.
Louis, K.S., Jones, L.M., Anderson, M.S., Blumenthal, D., Campbell, E.G., 2001. Entrepreneurship, secrecy and productivity: a comparison of clinical and non-clinical life sciences faculty. Journal of Technology Transfer 26 (3), 233–245.
Klofsten, M., Jones-Evans, D., 2000. Comparing academic entrepreneurship in Europe: the case of Sweden and Ireland. Small Business Economics 14, 299–309.
Marsden, P.V., 2005. Recent developments in network measurement'. In: Carrington, P.J., Scott, J., Wasserman, S. (Eds.), Models and Methods in Social Network Analysis. Cambridge University Press, New York, pp. 8–30.
Matasar, A.B., 2006. Women of Wine. The Rise of Women in the Global Wine Industry. University of California Press, Berkeley.
Mazzoleni, R., Nelson, R.R., 2007. Public research institutions and economic catch-up. Research Policy 26, 1512–1528.
Moguillansky, G., Salas, J.C., Cares, G., 2006. Innovacion en la industria del Vino. Corfo, Santiago de Chile.
Mora Valentin, E.M., 2002. A Theoretical review of co-operative relationships between firms and universities. Science and Public Policy 29 (1), 37–46.
Morrison, A., Rabellotti, R., 2007. The role of research in wine: the emergence of a regional research area in an Italian wine production system. International Journal of Technology and Globalisation 3 (2/3), 155–178.
Moulton, B.R., 1990. Random group effects and the precision of regression estimates. Journal of Econometrics 32, 385–397.
Mowery, D.C., Nelson, R.R., Sampat, B., Ziedonis, A., 2001. The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh–Dole act of 1980. Research Policy 30 (1), 99–119.
O'Shea, R., Allen, T., Chevalier, A., Roche, F., 2005. Entrepreneurial orientation, technology transfer and spinoff performance of U.S. universities. Research Policy 34 (7), 994–1009.
Owen-Smith, J., Riccaboni, M., Pammolli, F., Powell, W.W., 2002. A comparison of U.S. and european university-industry relations in the life sciences. Management Science 48 (1), 24–43.
Owen-Smith, J., 2005. Trends and transitions in the institutional environment for public and private science. Higher Education 49 (1), 91–117.
Perkmann, M., Walsh, K., 2007. University–industry relationships and open innovation: Towards a research agenda. International Journal of Management Reviews 9 (4), 259–280.
Santoro, M.D., Chakrabarti, A.K., 2002. Firm size and technology centrality in industry–university interactions. Research Policy 31 (7), 1163–1180.
Schartinger, D., Rammer, C., Fischer, M.M., Frohlich, J., 2002. Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants. Research Policy 31 (3), 303–328.
Van Rijnsoever, F.J., Hessels, L.K., Vandeberg, R.L.J., 2008. A resource-based view on the interactions of university researchers. Research Policy 37, 1255–1266.
Santos Silva, J.M.C., Tenreyro, S., 2006. The log of gravity. The Review of Economics and Statistics 88 (4), 641–658.
Velho, L., Saenz, W.T., 2002. R&D in the public and private sector in Brazil: complements or substitute? UNU/INTECH Discussion Papers, pp. 1564–8370.
Vink, N., Williams, G., Kirsten, J., 2004. South Africa. In: Anderson, K. (Ed.), The World Wine Markets: Globalization at Work. Edward Elgar, Cheltenham, pp. 3–37.
Wasserman, S., Faust, K., 1994. Social Network Analysis. Methods and Applications. Cambridge University Press, Cambridge.
Winetech, 2006. *Annual report*. www.winetech.co.za.
Whittington, K.B., Smith-Doerr, L., 2008. Women inventors in context. Gender and Society 22 (2), 194–218.
Zucker, L., Durby, M., 1996. Star scientists and institutional transformation: patterns of invention and innovation in the formation of the biotechnology industry. Proceedings of the National Academy of Sciences of the United States of America 93 (23), 12709–12716.

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