Why Do Researchers Collaborate with Industry? An Analysis of the Wine Sector in Chile, South Africa and Italy

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Abstract: This paper explores the determinants of the linkages between industry and research organizations – including universities. We present new evidence on three wine producing areas – Piedmont, a region of Italy, Chile, South Africa - that have successfully reacted to the recent structural changes experienced in the industry worldwide.

Based on an original data-set, we carry out an econometric exercise to study the microeconomic determinants of researchers' collaborations with industry. The evidence reveals that individual researcher characteristics, such as embeddedness in the academic system, age and sex, matter more than their publishing record or formal degrees.

Keywords: University-Industry Linkages, Innovation System, Wine Sector, Emerging Economies

1 Introduction

The wine sector has recently experienced a process of dramatic technological change and modernisation, spurred by the results of applied research from universities and research institutes, and increased interaction between researchers and the industry (Aylward, 2003; Giuliani, 2006; Morrison and Rabellotti, 2007; Unwin, 1991). These changes are occurring worldwide, with new producing areas emerging in countries as diverse as Argentina, Australia, Chile and South Africa among others. This evidence nicely matches with the increasingly prevalent "systemic" approach to innovation: scholars, practitioners and policy-makers are acquiring greater awareness that innovation occurs within a system, where continuous interactions among the various actors play an essential role.[1]

This paper contributes to one specific dimension of this literature, which is the relationship between industry and research organizations – including universities – and the determinants of these linkages. Universities and research institutes are increasingly seen as central actors in the economic development processes of countries and regions. Their role has always been crucial for the production of new ideas and knowledge and, recently, there has been much emphasis on their linkages with industry and on the importance of these relationships for economic development. Although it is true that university-industry (U-I) linkages[2] are not

1 See the literature on 'National Systems of Innovation' (e.g. Lundvall, 1992; Nelson, 1993) and its application to developing countries see, e.g.: Cassiolato *et al*., 2003; Lall and Pietrobelli, 2005; Lundvall *et al*, 2008; Mani, 2004; Muchie *et al*., 2003.

2 Although in our empirical analysis there are some public research organizations which are different from universities, in the rest of this paper we use the expression University (U) – Industry (I) linkages as it is commonly accepted in the relevant literature.

per se a recent phenomenon, it is equally true that they have increased considerable in the recent past (Etzkowitz, 1998). This may be due to an increased trans-disciplinarity of the knowledge production process requiring tight and continuous interaction between science and technology (Faulkner, 1994) and to policies in both the US and Europe – and increasingly in the developing countries – aimed at promoting interaction between research institutions and industry (Geuna, 2001; Mowery et al., 2001; Velho and Saenz, 2002; van Looy et al., 2003).

Within this framework, the empirical literature on developed countries has focused predominantly on patent-driven U-I collaborations, which have been investigated from the perspective of either the firm or the university involved. There has been little work done on other forms of interaction (e.g. research collaborations) and the roles of individual researchers in this interaction. Moreover, although it is widely acknowledged that most of the networks emerging out of these linkages are highly skewed, with some *star* researchers and prestigious universities strongly connected with the business world, and others with very few or no connections, there is still little evidence on *why* this happens and *what* determines such a network configuration. In order to fill this gap in the literature, and in line with some recent contributions on U-I linkages (Bercovitz and Feldman, 2003; D'Este and Fontana, 2007; D'Este and Patel, 2007), this study focuses on U-I research collaborations from the individual researchers' perspectives and explores their determinants. This is especially relevant as improved understanding of these mechanisms could inform policy makers about the design and implementation of public policy.

This study also contributes to the U-I literature by providing evidence on emerging economies. In particular, we provide new evidence on three wine producing contexts –Piedmont in Italy, Chile and South Africa - that have successfully reacted to the structural changes experienced in the industry worldwide. We exploit an original set of data collected by the authors through a questionnaire survey of researchers in these three wine innovation systems, and conduct an econometric analysis to study the microeconomic determinants of researchers' collaborations with the industry.

The evidence reveals that individual researchers' characteristics such as their embeddedness in the academic system, their sex and age matter, while their academic status, publishing record and formal education degrees are not significant. Working in a university, rather than in another type of research organizations, makes a positive difference, while other research organization characteristics do not appear to influence the emergence of U-I linkages.

The paper is organized as follows. Section 2 reviews the literature on U-I linkages and develops an original conceptual framework to explore the microeconomic determinants of the formation of these associations. Section 3 provides an overview of the wine industry in general 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

There is substantial empirical evidence showing that interaction between university and industry can occur through multiple channels, ranging from informal meetings, to researcher involvement in consultancy commissioned by the industry, to joint research programmes, to the licensing of patents and the purchase of prototypes developed by the industry (Bonaccorsi and Piccaluga, 1994; D'Este and Patel, 2007; Schartinger et al. 2002). However, most of the attention in the literature on knowledge transfer has been devoted to patenting, licensing and start-up companies, with relatively little empirical research on the microeconomic behaviour of individual researchers in the various types of relationships with industry. And, increasingly it is becoming clear that patent-driven collaborations represent a tiny portion of a wider set of relations that researchers establish with the industry in order to gain access to a variety of outputs (e.g. access to funding, information on user needs) (D'Este and Patel, 2007; D'Este and Fontana, 2007).

D'Este and Patel (2007) identify two sets of factors that can influence the formation of U-I linkages: first, the *individual characteristics of the academic researcher* (see, among many others, Agarwal and Hen-

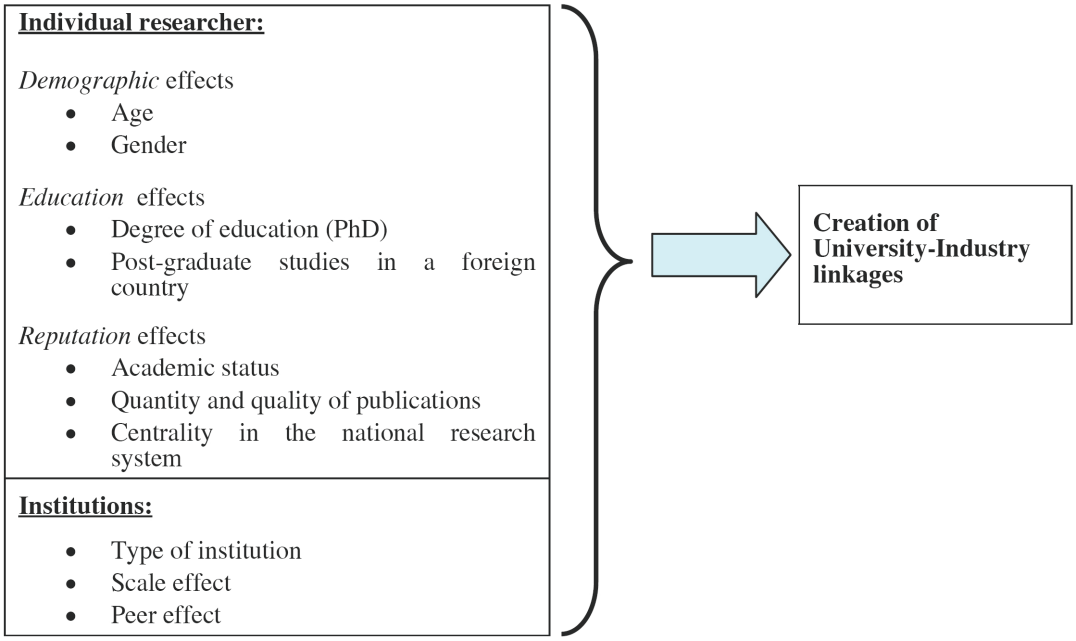

Figure 1 - Factors affecting the formation of U-I linkages

derson, 2002; Bercovitz and Feldman, 2003; Landry et al., 2007; Louis et al., 2001); second, the characteristics of *the institutions* – research organization, university, department - in which the researchers operate (Friedman and Silberman, 2003; Schartinger et al., 2002; Tornquist and Kallsen, 1994).[3] In this paper we follow this approach, as depicted in Figure 1.

3 Why the Wine Industry and Why These Regions

Establishing the extent and depth of the U-I interaction is usually facilitated by underlying research that is applied in nature; this tends to apply more to fields such as agronomy, engineering and the life sciences, than physics and mathematics, for instance. In this paper, we focus on scientific research into wine production.

In the past, the wine industry has undergone major structural industrial and market changes, which have been accompanied by a scientific and technological shift. The recent dramatic technological change and modernization that has occurred in the wine sector, known for being a traditional, craft-based activity, has been 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, 2006; Morrison and Rabellotti, 2007; Unwin, 1991).

Patterns of wine consumption have also changed, with market preferences shifting from quantity, non-premium wines to quality, premium wines. Production technology and grape growing and wine making techniques have undergone increased codification, which has allowed countries that formerly were 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 have become competitive in the international market, challenging 'old world' producers such as France, Italy and Spain (Anderson et al., 2003).

3 In addition, the extent, depth and variety of U-I linkages may also be affected by the sectoral context in which they occur. This includes the main features of the industry under analysis, such as, for example, whether industrial concentration or (perfect) competition prevails or the forms that competition may take. We do not enter into this discussion here, although we realize it could be significant in the emergence and development of U-I linkages.

Historically, public research organizations have played a central role in this industry. Institutions and researchers from the old world, primarily France but also Italy, led scientific research in this field for a long time. However, research has become increasingly international and several leading research centres in both viticulture and oenology have emerged around the world. Various authors (Aylward, 2003; Unwin, 1991) 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 a 'wine system of innovation' (Aylward, 2003) 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, 2006).

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 the production and export of wine. 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 production and trade. However, the quality of Chilean wine did not improve until the late 1990s (Bell and Giuliani, 2007).

Chile's success has been achieved thanks to a process of technological renovation, which has transformed an old market into a modern and dynamic, export-oriented industry - which today plays an important role in the country's economy. Significant investments to support innovation 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 funds (Moguillansky et al., 2006).

Recently, there has been an explicit policy objective of strengthening Chile's national wine research system through tight links between research organizations and the industry. In 2005, the establishment of two large technological consortia was promoted. These two consortia involve all the main business associations of wine producers and the main universities and wine related public research centres. It is the intention of the policy makers that these two consortia should play a key role in managing the research funding, selecting projects and promoting research to address very specific 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 have 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 demand pattern, 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 2004 it accounted for 3.1% of world wine production, and was ranked 4th among the 'new world' producers and 9th at world level (Anderson, 2006).

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 with their brands into fast growing markets (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 representing the interests of all stakeholders (i.e. producers, farmers, workers and wholesale merchants) and focusing on different strategic areas, such as R&D, marketing, human resources and social promotion.

Within this new institutional framework, a strategic role has been assigned to various technical and scientific organizations. Within SAWB is a division, the Wine Industry Network of Expertise and Technology (Winetech), which has explicit responsibility for promoting, financing and coordinating wine research. 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 the pillars of the South African wine research system absorbing more than 90% of its research funding (Winetech, 2006). Funding of 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. Thus, the unique structure of the South African institutional framework makes this country a particularly interesting case for the investigation of U-I relationships.

3.3 Italy (Piedmont)

Italy is a traditional wine producing country and one the world's leading wine producers, ranked second after France, and accounting for 18% of world production in 2004 (Anderson, 2006). Within Italy, we focus in this study on Piedmont, which produces some of the best known Italian wines (e.g. Asti Spumante, Barolo and Barbera) and is the second largest (after Veneto) exporting region in Italy, with a share of about 20 % of all Italian exports in 2005.[4]

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 preference 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 quite well, and holding its own in the face of external competition and changes in consumption patterns.

Due to its strong specialisation 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 regional level, there are a number of research institutions participating in 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, and especially *Vignaioli Piemontesi***,** the largest association of wine and grape producers in Italy, with more than 8,000 members. Vignaioli Piemontesi employs a team of technicians, mainly agronomists, who work closely with member firms and - particularly in small firms – take responsibility sometimes 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) showed that the wine innovation

4 The value of wine exports in Piedmont is US$700 million, placing the region between Chile which exports US$900 million and South Africa with US$530 million (Cusmano *et al*, 2008).

system in Piedmont is characterized by a core of R&D and extension organizations, which play a central in diffusing knowledge to a large number of firms, in an efficient manner.

4 Methodology

4.1 The Data

The study is based on original survey data collected in three areas - i.e. 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, spanning a number of disciplines (e.g. viticulture, oenology, agronomy, agriculture, microbiology, genetics, chemistry, engineering). The populations of researchers with these characteristics were selected for interview with the help of local experts and informants in the area. The sample includes 40 researchers in Chile, 42 in South Africa and 53 in Piedmont (Italy) (see Table 1 for affiliations of interviewees). This sample is relatively small, but 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 original 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 people in the industry. This background information on researchers'

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

Cile		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 N° of researchers	**40**		**42**		**53**

personal profiles also includes information on on her/his education and work experience (e.g. age, sex, years of experience in research, position, affiliations, level of education achieved). Relational data on collaborations were gathered in a specific section of the questionnaire, in a format suitable for social network analysis (Giuliani and Rabellotti, 2008), through the so called *free recall* method (Wasserman and Faust, 1994). Specifically, two types of relational data were sought: (i) data on U-I linkages between the interviewee and professionals in the industry; and (ii) data on academic linkages between the interviewee and other researchers in their own country. Respondents were asked whether they had collaborated with a researcher and/or a professional located in their country[5] and to specify the name and the main characteristics of the collaboration.

4.2 The Variables

The aim of the analysis was to explore the relation between researcher characteristics 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 that 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 the predictions expected, based on the evidence in the literature.

Dependent variable: *U-I Link*

The *dependent variable* (*U-I Link*) measures the number of linkages a researcher establishes with the industry, on the basis of the relational question reported in Appendix A.1. This variable is measured as the *Normalized degree of centrality (NDC)* of each researcher's U-I network. *U-I Link* is a continuous variable ranging from 0 to a maximum value of 3.70.

Independent variables:

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

Individual researcher

(i) 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;
- *Researcher's sex* is measured as a dummy variable (Male is 0; Female is 1), with an open prediction, given the absence of previous empirical evidence on this matter;

(ii) Training variables

- *PhD*: measuring the level of education of the researcher (i.e. holding a PhD) measured with a dummy variable that takes the value 1 if the researcher has a PhD and 0 otherwise. On the basis of the empirical evidence, predictions vary, therefore we leave it open;
- *Postgrad_abroad:* this variable takes the value 1 if the researcher's post-graduate studies were undertaken abroad, 0 otherwise. Again, the prediction is open;

5 In this study we focus on linkages within the country. For an analysis of linkages with researchers and professionals outside the country see Giuliani and Rabellotti (2008).

(iii) Reputation variables

- *Position*: this variable indicates the status of the researcher - 1 if the researcher has an appointment as Full Professor or Associate Professor at a university or is a Senior Researcher in a research institute, and 0 otherwise. Our expectation is that a 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 publications recorded in Thompson's Institute of Scientific Information (ISI) Science and Social Sciences Citation Indexes (SSSCI).[6] The publication records were obtained by matching the names of the researchers with articles in the ISI database, for 1990 to 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 authors' 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 a publications get more citations 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.1. This is measured as the normalized degree of centrality, as explained in the Appendix. We expect a positive relationship with U-I linkages;

Characteristics of institutions

- *Sizedep* and *Sizedepsq*: to test for a non-linear relationship between scale of the department, measured as the number of researchers in the department, and U-I linkages;
- P*eer effect*: for researcher *i* measured as the sum of the U-I linkages for the 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_inst*: this variable indicates the type of institution and takes the value 1 if it is a university and 0 for a research institution. This prediction is open.

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

5 Empirical Results

5.1 Descriptive Comparative Analysis of U-I Linkages for Chile, South Africa and Italy

In this section we provide a descriptive analysis of the researchers involved in U-I linkages, to investigate commonalities and differences across Chile, South Africa and Italy (Table 2). First, we can see that on average Chilean researchers maintain slightly more links with industry than 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 post-graduate degree, which is much lower than for Chile and South Africa.[7] Also, for Chile international education of researchers is statistically

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 also results in some major limitations to the study. In fact, 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, introduced only in the 1980s.

significantly different from South Africa and Italy: 60% of Chilean researchers obtained a university degree abroad.

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).

As we can see from Table 1, in terms of institutions to which researchers are affiliated, Chilean researchers are mainly based in universities, while in Italy and South Africa 40% of the researchers interviewed were based in other research institutions, such as the research centres related to the Ministry of Agriculture (both Italy and South Africa) and the National Research Council (Italy). 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 in the three areas. In Italy and Chile, the most frequent type of association is joint research agreement, while in South

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

	Dep Var	**Demo-graphic**		**Training**		**Reputation**				**Institutions**		
	U-I Link per researcher	***Age*** avg.	***Sex*** % male	***PhD*** %	***Post-grad abroad*** (%)	***Position*** (%)	***TNP***	***QTP***	***Acad_ centr***	***Sizedep*** (avg. n°. of researchers)	***Peer effect***	***Type_inst*** (% Universities)
Chile	4.42	48.2	82.5	68.0	60	55.0	6,63	4,47	3.38	85.35	1.23	90%
Italy	2.66	46.5	77.8	28.0	3.7	46.0	5,11	4,69	2.78	47.5	1.49	61%
South Africa	3.07	43.0	76.2	64.0	14	36.0	6,10	2,92	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.

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 (0.47)	64 (0.36)	25 (0.19)
(ii) Contract research agreements	20 (0.14)	36 (0.20)	31 (0.24)
(iii) Consultancy work	14(0.10)	31 (0.18)	24 (0.19)
(vi) Informal contacts	24 (0.17)	19 (0.11)	31 (0.24)
(v) Attendance at conferences	12 (0.08)	10 (0.06)	5 (0.04)
(vi) Participation in electronic networks	0 (0.00)	0 (0.00)	0 (0.00)
(vii) Setting up of spin-off companies	0 (0.00)	0 (0.00)	3 (0.02)
(viii) Training of company employees	1 (0.01)	11 (0.06)	6 (0.05)
(ix) Student internship in firms	6 (0.04)	6 (0.03)	4 (0.03)
Total links	144	177	129

Africa research contracted by the industry and undertaken by the 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. In the next section we present the econometric analysis, which highlights the characteristics of the researchers and their links with the industry.

5.2 The Econometric Analysis

5.2.1 Results

Here, we present the main results of the econometric exercises in an attempt to test the importance of the different groups of variables on the formation of U-I linkages, for Chilean, South African and Italian researchers specialised in wine related subjects. Table 4 presents different specifications of the model based on the groups of variables identified in the literature as the main factors influencing U-I linkages. Model 1 includes only demographic variables, Model 2 adds the training variables, Model 3 includes the reputation variables and Model 4 includes the variables related to the characteristics of the institutions. The main results for each set of variables are described 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, in our model, the expected U-shaped relationship is not confirmed. This suggests that younger scholars are more likely to form U-I linkages compared with their older colleagues. Interestingly, women are more likely to form linkages with the industry than their male colleagues, as indicated by the positive and significant coefficient of the variable *Sex*.

None of the training effects – i.e. having a PhD and/or having undertaken post graduate studies in a foreign country – is statistically significant.[8] Among reputation effects, centrality in the domestic academic network (*Acad_centr*) is significant and positive, but neither researcher's status (*Position*) nor her/his academic excellence (number of publications *TNP* and average number of citations *QTP*) is significant.

For institutional affiliation, Model 4 suggests that the only significant variable is the dummy distinguishing between universities and other research institutions (*Type_inst*); it seems that university researchers enter into more U-I linkages than researchers from other types of institutes. However, neither the size of the department nor the peer effect is significantly related to the formation of U-I linkages.[9]

Finally, the dummy control variables for Chile (*DCH*) and Italy (*DIT*) are both negatively and statistically significant in all four models.

5.2.2 Discussion of Results

The results of the econometric exercise allow us to draw some interesting conclusions. In general, it is the characteristics of the individual researchers, such as age and sex, that seem to determine U-I linkages, rather than educational background, academic status or publication performance. There are two plausible explanations: first, the latter aspects are not perceived or are only superficially valued by professionals in

8 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 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

9 It should be noted that *Type_Inst* absorbs the effect of *Peer*, which is significantly correlated with the dependent variable (see the correlation matrix in the Appendix). In fact, there is a strong relationship between *Type_Inst* and *Peer* (*p*-value for the ANOVA is 0.082), 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* is systematically higher in universities than in other organizations.

Table 4 The Poisson estimation of the determinants of I_U linkages

Variables	Model 1	Model 2	Model 3	Model 4
a) Demographic variables				
Age	-0150194*** (.00338)	-.0150785*** (.00417)	-.0163543*** (.00450)	-.0108003* (.00653)
Agesq.	.00013 (.00059)	-.000032 (.00066)	-.0000171 (.00076)	9.60e-06 (.00079)
Sex	.116046** (.05272)	.1116865* (.06732)	.1208809* (.07006)	.1192763 *** (.03957)
b) Training variables				
PhD		-.1263165 (.18785)	-.1286381 (.142067)	-.2496669 (.23186)
Postgrad_abroad		.1496507 (.34767)		
c) Reputation variables				
Position			.2625439 (.23793)	.1196949 (.24513)
TNP			.0108492 (.00920)	.0071591 (.00700)
QTP			-.0004341 (.0044701)	-.0053484 (.00375)
Acad_centr			.1228068*** (.03173)	.1053611** (.04298)
d) Characteristics of institutions				
Type_inst				.2008061 *** (.04218)
Sizedep				-.0035615 (.00526)
Sizedepsq				.000022 (.00002)
Peer effect				.0081867 (.00698)
e) Control variables				
DCH	-.8374153*** (.01509)	-.8963006*** (.12547)	-.8325766*** (.19019)	-.6670667 ** (.23424)
DIT	-.7186895*** (.01136)	-.7465869*** (.05900)	-.5771265*** (.19019)	-.4967342*** (.09737)
Constant	.8315451 (.19142)	-.8958582 (.24252)	-.2582145 (.35481)	.1698557 (.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.

the industry; and second, it is possible that professionals with higher academic degrees and higher scientific quality do not engage in very applied research oriented at solving the practical matters of the industry, to any great extent.

On the other hand, we find that centrality of the researcher in the national research system is highly significant. This may be because, first, centrality in the academic network might indicate an active relational propensity, which might mean that the researcher is also involved in other types of linkages. We would expect these researchers to be embedded in a dense network of research linkages, and to have higher chances of being informed about and eventually involved in projects with industry than less well connected ones. And second, because centrality in the academic system may be the way that the eminence of the researchers is signalled to industry, via word of mouth through formal or informal interaction. Hence, central researchers are more visible to professionals in the industry.

It should be remembered that the wine innovation systems being investigated are quite small and comprise a relatively small number of researchers and firms. Thus, it is plausible that the most 'central; researchers in these innovation systems also enjoy the highest standing with the industry, and that for the industry this is more prominent than are the details of their publishing performance. Furthermore, linkages with the most central researchers five firms access to a larger community of academics, which, in turn, increases their opportunities to obtain novel information and establish further research collaborations.

Finally, the characteristics of the research organisations where researchers work appear to influence U-I linkages to a lesser extent. Only working in a university shows a (positive) difference, perhaps related to the university mission of supporting regional development through applied research. This result should be read in light of the fact that, as explained before, the variable *Type_inst* absorbs the 'peer effect', that is, the degree to which the researcher's colleagues interact with the industry. Therefore, imitating the behaviour of other colleagues encourages researchers to have more interactions with the industry. With regard to the scale of the department, this does not appear to affect the likelihood of U-I linkages, confirming the results of other studies (D'Este and Patel, 2007).

Finally, the results confirm that the South Africa wine innovation system appears especially to reward strong U-I linkages. This can be explained by the organization of the South African institutional framework in the wine sector, and the purposeful establishment of Winetech with a mandate to promote, coordinate and finance research for the wine industry, which is unique among these three countries. Winetech coordinates the industry's research requirements and conveys them to the research community, selecting which research projects will be financed. The funds allocated by Winetech are the main source of finance for research on wine-related issues in South Africa.[10] This specificity of the institutional setting could be justification for the strong orientation of the South African research system, towards the industry.

6 Conclusions

This paper contributes to the literature on the microeconomic determinants of U-I linkages, and therefore also to the understanding of a key dimension of national systems of innovation. Though academic research institutions have long served as a significant external source of scientific and technical knowledge for industrial firms, the intensity and variety of activities at the university–industry interface is growing, and it is crucial to improve understanding of how and why university researchers interact with firms. In this paper we develop an original, and rich conceptual framework that has the advantage that it tests how the characteristics of both the individual researcher and of her/his organization influence collaboration with industry. Also, this study focuses on developing countries and adopts a systemic approach to innovation

10 Winetech is largely financed by an export levy that applies to all exporters. In 2006 the total income was approximately RAND17 million (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).

and its diffusion. There are very few similar studies in the literature. The empirical evidence leads to several important results.

First, researchers from all the regions considered here are very active in making research links with industry. Disparities across countries at different levels of development seem to matter less than the most prominent common characteristics of a specific sector, such as wine, where applied scientific research plays a central role. The three countries examined are all key players in the world market and, although, on the basis only of the investigation in this paper, we cannot conclude whether the extent, variety and depth of U-I linkages mark differences in industry or innovation performance, we can reasonably claim that their existence is a sign that both parties benefit from this interaction. Future research will further explore this in detail.

Second, researchers' individual characteristics matter more in determining U-I linkages than the context and the organization in which they operate. The most influential factors affecting collaboration of researchers with industry appear to be younger age, being female and 'centrality' in the academic system. Younger scholars show a higher 'openness' towards the professional and productive world, which in the future could possible lead to greater fluidity of interaction between the academic and professional communities – once considered two different worlds. It would be interesting in future research to deepen the analysis of researchers' personal characteristics and careers, as this may have some influence on the intensity of their interactions with industry.

Although this analysis was on a specific sector – the wine industry – it can be generalised to any sectors that rely strongly on applied science and are undergoing substantial restructuring at global level. The analysis is interesting in terms of its implications (although preliminary and tentative) for policy design. First, promoting linkages with the industry of a few researchers with central positions in the academic network may have a positive impact on the whole system, and might help diffuse innovation through the industry. However, this also raises the question of the vulnerability of the system: these central researchers might leave the country or the sector, which would considerably weaken the whole innovation system. This would apply particularly to small research systems, involving only a few central researchers.[11] Second, in an applied field such as wine science, 'entrepreneurial' researchers, open to commercial interactions with industry, also maintain strong linkages within the academic community. This provides some empirical support for the idea of complementarities between academic research and industrial relationships. Thus, our findings would suggest that there is no trade-off between linkages between academic fellows and links with industry.

Third, we consider all types of U-I linkages, from research collaborations to training, without differentiating their variety. The variety of these links should be explored in future work, as the motivations underlying a U-I linkage established for joint research purposes might be different from those relating to consultancy or student internships.

7 Acknowledgments

Preliminary drafts of this paper were presented at the ALTEC Conference in Buenos Aires (2007) and the AISRE Conference in Bolzano, Italy (2007). The authors would like to thank: Massimo Pernicone and Gabriela Cares for their collaboration in the collection of data. Moreover, we are grateful to Eric Wood for his assistance in organising the field work in South Africa and for his comments on the questionnaires. In South Africa we also thank Nick Vink. In Chile, thanks go to Mario Castillo, Jimena Gonzalez Alvarado, Pablo Ugarte Cruz Coke from CORFO and to José Miguel Benavente and Graciela Moguillansky for their support in the field research. Financial support from Progetto Alfieri – Fondazione CRT is gratefully acknowledged.

11 South Africa is a case in point, with the specific example of a former director of the Institute of Biotechnology at the University of Stellenbosch, who moved to Australia to become the managing director of the Australian Wine Research Institute.

References

Anderson, K. (2006). 'Compendium of Wine Statistics', mimeo.

Anderson, K., Norman, D. & Wittwer, G. (2003). 'Globalisation of the World's Wine Markets', *The World Economy* Vol. 26, No. 5, pp. 659-87.

Agarwal, A. & Henderson, R. (2002). 'Putting patents in context: Exploring knowledge transfer from MIT', *Management Science* Vol. 48, No. 1, pp. 44-60.

Aylward, D.K. (2003). 'A Documentary of Innovation Support among New World Wine Industries', *Journal of Wine Research* Vol. 14, No. 1, pp. 31-43.

Balconi, M., Breschi, S. & Lissoni, F. (2004). 'Networks of Inventors and the Role of Academia: an Exploration of Italian Patent Data', *Research Policy* Vol. 33, pp. 127-45.

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* Vol. 3, No. 2/3, pp. 197-223.

Bercovitz, J. & Feldman, M. (2003). ;Technology Transfer and the Academic Department: Who Participates and Why', mimeo.

Bonaccorsi, A. & Piccaluga, A. (1994). 'A Theoretical Framework for the Evaluation of University- Industry Relationships', *R&D Management* Vol. 24, No. 3, pp. 229-247.

Cassiolato, J.E., Lastres, H. & Maciel, M. (Eds.) (2003). 'Systems of Innovation and Development: Evidence from Brazil', Edward Elgar, Cheltenham.

Cole, J. & Zuckerman, H. (1984). 'The productivity puzzle: persistence and change in patterns of publications of men and women scientists', *Advances in Motivation and Achievement* Vol. 2, pp. 217-258.

Cusmano, L., Morrison, A. & Rabellotti, R. (2008). 'Catching up in Sectoral Systems of Innovation. A Comparative Study of the Wine Sector in Chile and South Africa', Mimeo. Department of Economics and Quantitative Methods, University of Piemonte Orientale, Novara.

D'Este, P. & Fontana, R. (2007). 'What Drives the Emergence of Entrepreneurial Academics? A Study on Collaborative Research Partnerships in the UK', *Research Evaluation* Vol. 16, No. 4, pp. 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* Vol. 36, No. 9, pp. 1295-1313.

Etzkowitz, H. (1998). 'The Norms of Entrepreneurial Science: Cognitive Effects of the New University-Industry Linkage', *Research Policy* Vol. 27, pp. 823-833.

Faulkner, W. (1994). 'Conceptualizing knowledge used in innovation: A second look at the science-technology distinction and industrial innovation', *Science, Technology, & Human Values* Vol. 19, No. 4, pp. 425-58.

Friedman, J. & Silberman, J. (2003). 'University technology transfer: Do incentives, management, and location matter?', *Journal of Technology Transfer* Vol. 28, No. 1, pp. 17-30.

Geuna, A. (2001). 'The changing rationale for European university research funding: Are there negative unintended consequences?', *Journal of Economic Issues* Vol. 35, No. 3, pp. 607-632.

Giuliani, E. (2006). 'Efficient 'Public Research Organization-Industry' Network Structures? A Comparative Study in the Chilean and Italian Wine Industry', Series: European Forum, EUI Working Paper, RSCAS 2006/07, European University Institute, Florence.

Giuliani, E. & Rabellotti, R. (2008). 'Academic and I-U networks in the wine industry: A comparative Analysis of Italy, Chile and South Africa', Mimeo, Department of Economics and Quantitative Methods, University of Piemonte Orientale, Novara.

Gonzalez-Brambila, C. & Veloso, F.M. (2007). 'The determinants of research output and impact: A study of Mexican researchers', *Research Policy* Vol. 36, No. 7, pp. 1035-1051.

Gulbrandsen, M. & Smeby, J-C. (2005). 'Industry funding and university professors' research performance', *Research Policy* Vol. 34, No. 6, pp. 932-950.

Lall, S. & Pietrobelli, C. (2005), 'National Technology Systems in Sub-Saharan Africa', *International Journal of Technology and Globalisation* Vol. 1, No. 3/4, pp. 311-342.

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* Vol. 32, No. 6, pp. 561-592.

Levin, S. & Stephan, P. (1991). 'Research productivity over the life cycle: evidence for academic scientists', *The American Economic Review* Vol. 81, pp. 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* Vol. 33, No. 2, pp. 209-229.

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* Vol. 26, No. 3, pp. 233-245.

Lundvall, B.Å. (1992). 'National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning', Pinter, London.

Lundvall, B.Å., Joseph, K.J., Chaminade, C. & Vang, J., (Eds.) (2008). 'Handbook on Innovation Systems and Developing Countries', Edward Elgar, Cheltenham. forthcoming.

Mani, S. (2004). 'Government, innovation and technology policy: an international comparative analysis', *International Journal of Technology and Globalisation* Vol. 1, No. 1, pp. 29-44.

Marsden, P.V. (2005). 'Recent Developments in Network Measurement', In: P.J., Carrington, J. Scott and S. Wasserman (Eds.), *Models and Methods in Social Network Analysis,* Cambridge University Press, New York, pp. 8-30.

Mazzoleni, R. & Nelson, R.R. (2007). 'Public research institutions and economic catch-up', *Research Policy* Vol. 26, pp. 1512-1528.

Moguillansky, G., Salas, J.C. & Cares, G. (2006). 'Innovacion en la industria del Vino', Corfo, Santiago de Chile.

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* Vol. 3, No. 2/3, pp. 155-178.

Moulton, B.R. (1990). 'Random Group Effects and the Precision of Regression Estimates', *Journal of Econometrics* Vol. 32, pp. 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* Vol. 30, No. 1, pp. 99-119.

Muchie, M., Lundvall B.Å. & Gammeltoft, P. (Eds.) (2003). 'The Making of African Innovation Systems', Aalborg University Press, Aalborg. www.globelics.org/index.php?module=htmlpages&func=display&pid=3.

Nelson, R.R. (ed.) (1993). 'National Innovation Systems: A Comparative Analysis', Oxford University Press, New York.

Schartinger, D., Rammer C., Fischer, M.M. & Frohlich, J. (2002). 'Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants', *Research Policy* Vol. 31, No. 3, pp. 303-328.

Tornquist, K.M. & Kallsen, L.A. (1994). 'Out of the Ivory Tower - Characteristics of Institutions Meeting the Research Needs of Industry', *Journal of Higher Education* Vol. 65, No. 5, pp. 523-539.

Unwin, T. (1991). 'Wine and the Vine: A Historical Geography of Viticulture and the Wine Trade', Routledge, London.

Velho, L. & Saez, W.T. (2002). 'R&D in the public and private sector in Brazil: complements or substitute?', UNU/INTECH Discussion Papers, 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.

Xie, Y. & Shauman, K. (1998). 'Sex differences in research productivity: new evidence about an old puzzle', *American Sociological Review* Vol. 63, pp. 847-870.

Appendix

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_inst
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	(0.316s)	(**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_inst	(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. Statistically significant correlations are indicated in bold.