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# Do funding sources matter?: The impact of university-industry collaboration funding sources on innovation performance of universities

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## ABSTRACT

The nature of funding sources for university-industry collaboration (UIC) has gradually changed, which may motivate universities to pursue different goals. Therefore, a question arises concerning whether and how funding sources influence the innovation performance of universities. This study explicates this relationship by using organisational control theory. Results of structural equation modelling using partial least squares based on a sample of 146 Taiwanese universities revealed that both governmental and industrial funding facilitated UIC management mechanisms and regulation implementation, which subsequently influenced the innovation performance of universities. Moreover, governmental funding has a greater impact on implementing UIC regulations and industrial funding has a greater impact on building UIC management mechanisms. The results also revealed that only industrial funding exerts a positive influence on the innovation climate of a university. Policy implications are discussed at the end of this paper.

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## 1. Introduction

University-industry collaboration (UIC) has been considered as an important factor in driving industrial innovation and the welfare of a country (Guan, Yam, and Mok 2005). Both universities and firms can benefit from UIC, such as through improved innovation performance (Kobarg, Stumpf-Wollersheim, and Welpé 2018). On the university side, government has always played a dominant role in resource funding that has driven universities to transfer and commercialise academic outcomes to industries (Gulbrandsen and Smeby 2005). Although the government is still a primary source for university funding, patterns of funding are changing (Auranen and Nieminen 2010). For example, in Australia, Canada, the United Kingdom, the United States (U.S.), and China, governmental funding is allocated on the basis of university performance and industrial funding is mission-oriented and contract-based (Auranen and Nieminen 2010; Slaughter and Leslie 1997). Furthermore, university research funded by private companies is increasing among the countries in the Organization for Economic Co-operation and Development (OECD) (Auranen and Nieminen 2010).

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While changes to funding sources may affect the nature of the UIC relationships and lead to unintended consequences, particularly regarding innovation performance of universities (Geuna 2001), few studies have clarified how differences in funding sources affect universities. For example, Gulbrandsen and Smeby (2005) investigated the relationship between different funding sources and faculty output and found no straightforward mechanism connecting funding incentives to research activity. A recent study has suggested that different funding sources influences the degree of patent originality (Guerzoni et al. 2014). Though the literature has focused on the influence of funding sources on faculty outputs, the influences of different funding sources on university innovation performance remain unclear.

To address the aforementioned questions, this study explored whether different funding sources (i.e. government or industry) would lead to different effects on universities, and how different funding sources trigger innovation performance of universities through different control mechanisms. This study used organisational control theory as the theoretical lens to explicate the previously mentioned relationship. In discussing organisational control theory in the UIC context, three control mechanisms were proposed and examined, namely the UIC management mechanism, UIC regulation implementation, and innovation climate of the university.

For empirical analysis, this study conducted a survey of 146 universities in Taiwan. This sample context was adopted because the Taiwanese government has created various regulations and management structures for boosting UIC and innovation performance of universities. Overall, this study makes several contributions to the literature. First, the results of this study highlight whether and how different funding sources influence the innovation performance of universities according to a dual path model. Second, the results elucidate how different funding sources affect different control mechanisms and innovation performance, which has received little attention in the literature.

The rest of this paper is organised as follows. Section 2 reviews the literature related to funding sources and the innovation performance of universities involved in UIC and proposes nine hypotheses. The research context, data collection, and measurement of our constructs are described in Section 3. Section 4 explains the data analyses conducted using structural equation modeling (SEM) and partial least squares (PLS) to evaluate the suitability of the research model for our purposes and then presents the empirical results and interpretations of the data. Finally, Section 5 concludes with the findings of this study.

## 2. Literature and hypotheses

### 2.1. Funding sources for university-industry collaboration

Funding sources are defined as financial support for UIC activities; they are obtained from the government or industry for different purposes. For instance, the Taiwanese government subsidises universities to enhance UIC programmes and develops UIC infrastructure for encouraging universities to cooperate with firms in various industries. Firms also provide financial assistance to universities for purchase or use of research equipment for undertaking technology innovation activities. Because universities are nonprofit institutions, the funding for UIC activities is a major source of income for universities. Funding for UIC can be classified as either internal or external (Auranen and Nieminen 2010). Internal funding refers to core funds over which universities have full discretion for allocation within universities, such as university assets, whereas external funding refers to public and private funding that is not considered part of core university funds, such as public project funding or grants from public funding agencies and contracts with public administration organisations. Payne and Siow (2003), Huang et al. (2005), and Goldfarb (2008) have suggested a positive relationship between governmental research funding and research outcomes. The results seem self-evident: researchers with funding support are more productive than those with no funding as initiation of UIC activities requires considerable expenditure (Gulbrandsen and Smeby 2005). However, funding patterns are gradually changing in ways that may affect outcomes.

As previously stated, although governmental funding is still the primary research funding source for Taiwanese universities, it is limited and most of the funding is allocated to the top universities, thereby increasing the competition for funds among universities. Thus, the maintenance of financial independence is vital when academic institutions are seeking funds from different sources, such as those from industry (Zajkowski 2003). Changes in funding sources suggest that the nature of the UIC relationships may also change. For example, the government may not play as dominant a role in UIC programmes funded by industries. In addition, universities may have different expectations and desired outcomes for UIC programmes. Therefore, it is critical to understand if and how different funding sources influence different control mechanisms and university innovation performance.

## 2.2. Innovation performance of universities

Universities are expected to not only produce new knowledge and technology but also achieve social and economic goals with their knowledge (Laredo 2007; Metcalfe and Ramlogan 2005). To realise economic benefits, various institutional and organisational innovations have flourished in academies, including the development of intellectual property and the establishment of technology transfer and licensing offices, incubator facilities, and spin-offs. Such measures indicate the realisation of innovation performance within universities. This study used four indicators for innovation performance of universities in the UIC context.

The first two indicators are *licensing patents* and *issued patents*. Although faculty and students spend most of their time engaged in basic research, they are encouraged to apply for and commercialise patents. An increasing number of academic inventions demonstrate immediate commercial potential and university knowledge bases have become new sources of industrial innovation (Sanz-Menéndez and Cruz-Castro 2003). Current patents have become a focus of discussion because they can be represented as technology innovation indicators. Patent data are readily available and conceptual and operational tools are increasingly well documented. The most crucial advantage of patents is that they represent a direct outcome of inventions for commercial usage (Archibugi and Pianta 1996).

The third indicator is the amount of *intellectual property-derived income*. This indicator reflects the economic performance generated from universities' intellectual property, such as licensing fees and royalties (Geuna and Nesta 2006). In practice, when new technologies are invented, universities often ask faculty, staff, and students to file invention disclosures. When a potential licensee is interested in contracting a specific technology, the licensing officer negotiates the terms of the contract (Sine, Scott, and Di Gregorio 2003). Between 1982 and 2000, the number of U.S. patents granted to university inventors increased from 500 to nearly 3800, indicating that university technology licenses generate substantial economic value. With the development of university technology licensing, intellectual property arrangements have substantial effects on the university sector, a phenomenon that certainly deserves more attention.

The final indicator is the establishment of a *business incubator*. A business incubator is a value-added tool employed by entrepreneurial universities (Mian 1996) with three main goals: transfer of technology, commercialisation R&D outcomes, and promotion of entrepreneurship (e.g. fostering new business development) (McAdam and Marlow 2008). Therefore, from a policy perspective, the establishment of a business incubator within a university reflects the efforts of a university to build infrastructure intended to formally stimulate university research outcomes. Prior literature has suggested that university business incubators typically focus on commercialising university research results while simultaneously fostering local business development, particularly with small business entrepreneurship (Allen and McCluskey 1991; Malecki 1991).

We measure university innovation performance using the previously described indicators. Specifically, we use the number of issued and licensing patents to identify the degree of science and technology development in a university and the amount of intellectual property-derived income and the

number of business incubators to understand the degree of commercial linkage between universities and industry. All these output-orientated indicators facilitate the evaluation of university innovation performance.

### **2.3. Influences of funding sources on control mechanisms and innovation performance of universities**

Organisational control is defined as a mechanism utilised by managers to motivate organisational members to act in accordance with the company's requirements (Cardinal 2001; Snell 1992). Prior literature has identified several types of organisational control. For example, Owen-Smith (2003) introduced the notion of scientific skepticism as a type of organisational control in ambiguous managerial situations. Within a bureaucratic framework, organisational controls are arranged in a top-down manner in the form of articulated operating procedures. Similarly, to ensure that subordinates adhere to procedures, superiors should closely monitor and evaluate their actions. Under the assumption of a centralised hierarchy, different types of control have been labelled as structural control (also called bureaucratic or behaviour control) (Lebas and Weigenstein 1986), input control (Mintzberg 1986), output control (Jaworski 1988), market control (Williamson 1975), cultural control (Wanous 1980), and integrative control (Roth, Sitkin, and House 1994). In this study, three types of control patterns were investigated in the UIC context: UIC management mechanism, UIC regulation implementation, and innovation climate within the university.

#### **2.3.1. UIC management mechanism**

Based on prior literature (Boardman 2009; Ring and Van de Ven 1994; Thune and Gulbrandsen 2011), a UIC management mechanism is defined as a structured management mechanism that regulates the standardised routine of the UIC relationship, such by controlling and coordinating the UIC. Corley, Boardman, and Bozeman (2006) propose funding as both a resource and demand for institutionalisation that articulates and supports the creation of a stable management mechanism. We propose that both governmental funding and industrial funding can be considered both resources and demands and, therefore, the two funding sources have positive influences on UIC management mechanisms.

Furthermore, prior literature has suggested that institutionalisation improves university-industry interaction (Corley, Boardman, and Bozeman 2006; Thune and Gulbrandsen 2011; Youtie, Libaers, and Bozeman 2006). For example, Corley, Boardman, and Bozeman (2006) have suggested that when a university and industry represent different fields or exhibit different norms, the development of a structured management mechanism for UIC improves the collaborative relationship. Enhancement of the UIC management mechanism is also likely to facilitate university involvement in more value-added activities, such as commercialising their research outcomes.

H1: Governmental funding is positively related to the UIC management mechanism.

H2: Industrial funding is positively related to the UIC management mechanism.

H3: The UIC management mechanism is positively related to the innovation performance of universities.

#### **2.3.2. UIC regulation implementation**

UIC regulation implementation is defined as a university's implementation of UIC regulation. Agency theory argues that organisations involve monitoring of member behaviour and impose stipulations on how activities are conducted (Eisenhardt 1985). Behaviour control has been extensively studied and is typically associated with the rules and regulations designed to ensure that member behaviour aligns with the goals of managers. The two main aspects of behaviour control are formalisation and centralisation; formalisation refers to the extent to which rules are codified and explicitly written into regulations whereas centralisation refers to the extent to which decision-making authority is granted to agents. Strong bureaucracies are considered highly formalised and centralised. As previously

mentioned, governmental and industrial fundings are both resources and demands that trigger UIC regulation implementation.

Regarding the influence of UIC regulation implementation on innovation performance of universities, innovation requires the simultaneous regulation of autonomy and control to promote creativity (Feldman 1989). Cardinal (2001) found that regulation implementation improves the outcomes of radical innovation ventures in the pharmaceutical industry. Thus, the present study proposed that the implementation of UIC regulation facilitates innovation performance.

H4: Governmental funding is positively related to UIC regulation implementation.

H5: Industrial funding is positively related to UIC regulation implementation.

H6: UIC regulation implementation is positively related to university innovation performance.

### **2.3.3. Innovation climate within universities**

In the context of UIC, innovation climate within universities refers to support for innovative activities within a university that influence the intrinsic motivation of individuals or teams engaged in entrepreneurial activities. Such support may include establishing entrepreneurship programmes, offering courses or workshops in entrepreneurship, or sponsoring venture competitions. This study proposed that governmental and industrial funding are necessary resources and supports as well as critical antecedents of an innovation climate (Hsu and Fan 2010; Hunter, Bedell, and Mumford 2007) and thus enhance the innovation climate within universities.

Moreover, the literature has also suggested a strong link between innovation climate and innovation performance (Hsu and Fan 2010; Hunter, Bedell, and Mumford 2007). For example, a climate that emphasises learning development and participatory decision making is positively correlated with higher innovativeness in an organisation (Kenney and Goe 2004). If students and teachers perceive that a university provides the necessary support for entrepreneurial activities, they may attempt to be creative at work and eventually complete innovation tasks. Therefore, we expect that the innovation climate within a university has a positive influence on the innovation performance of the university.

H7: Governmental funding is positively related to the innovation climate within a university.

H8: Industrial funding is positively related to the innovation climate within a university.

H9: The innovation climate within a university is positively related to university innovation performance.

On the basis of the preceding hypotheses, [Figure 1](#) depicts the proposed relationship among variables.

## **3. Methods**

### **3.1. Research context**

Since our study was designed to explore the impact of funding sources for UIC on innovation performance of universities, we conducted a survey of Taiwanese universities that have been actively engage in UIC for many years. The use of Taiwanese universities is appropriate for two reasons.

First, the Taiwanese government has regulated many UIC management structures. The Science and Technology Basic Act, established in 1999, is a related incentive programme that allows universities to claim partial or full commercialised intellectual property rights derived from governmental funding. Universities have attempted to shift from theory-orientated education to application-orientated education (Hu and Mathews 2009). In 2006, the Executive Yuan of the Republic of China proposed an incentive programme, the Inter-Ministerial Project, to boost Taiwan's economic development. This project spanned across three phases from 2007 to 2015. One of the purposes of the policy was to improve collaboration among universities, industries, and the government.

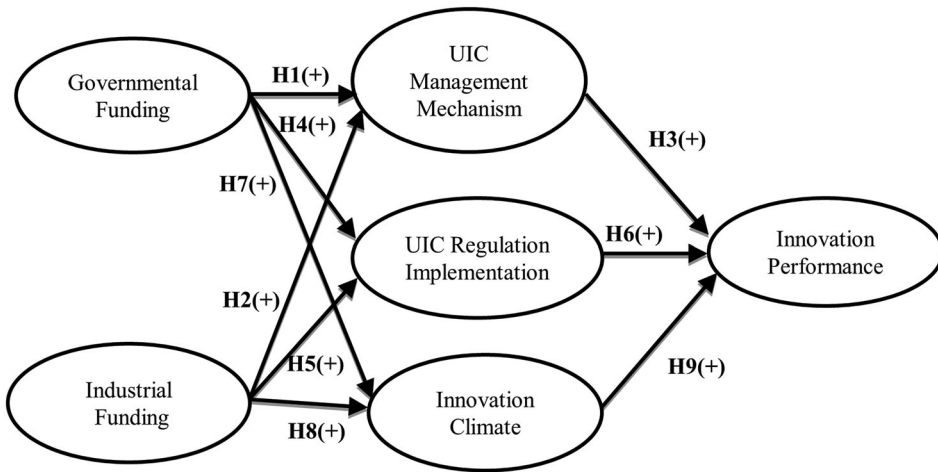


Figure 1. Research framework.

Governmental funding in Taiwan has increased dramatically since 2007. The Ministry of Education, in particular, has offered many programmes for directly promoting the development of UIC activities and innovation-related activities to improve university-industry linkages, such as the Small Business Innovation Research Promoting Program and Information Technology Applications Promotion Project. These government efforts motivate universities to establish the necessary infrastructure for effectively executing UIC projects.

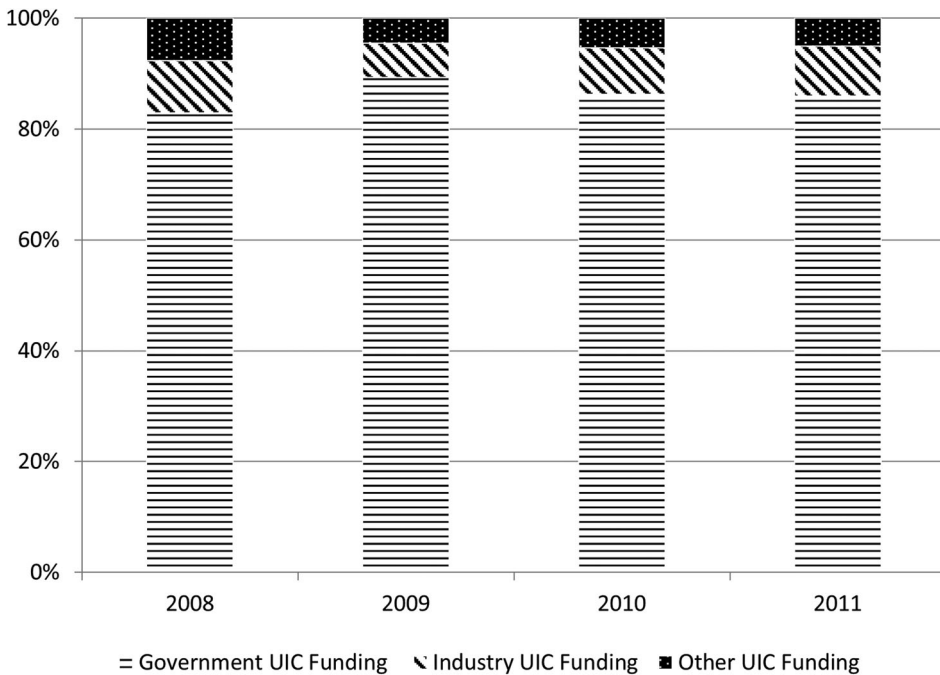


Figure 2. The percentages of government and industry funding for UIC with respect to the total budgets of universities in Taiwan (Source: UIC database 2008–2011).

Second, the Taiwanese government provides numerous incentive programmes for encouraging UIC. Figure 2 presents the percentage of government and industry funding for UIC with respect to total university budgets in Taiwan. Combined governmental and industrial funding for UIC exhibits a proportional increase within budget totals. The percentage of government funding increased dramatically in 2009, indicating the emergence of the overlapping activities among universities and industries and increased collaborations. The percentage of industrial funding increased dramatically in 2010 and 2011, indicating that the government catalyzes UIC. The government directs academic R&D energy to industries to establish a high-quality talent bank, driving the industrial economy toward knowledge and innovation and enhancing the nation's competitive advantage. Thus, we consider this a viable context to investigate the potentially diverse impacts of funding sources on university innovation performance.

### 3.2. Data

Two datasets were combined in this study to avoid the bias that emerges from single-source data. First, this study used a questionnaire to collect data for the UIC management mechanism, UIC regulation implementation, and the innovation climate. A total of 163 universities were identified from the Ministry of Education Directory of Higher Education Institutions in 2011. The questionnaire was distributed to 163 directors of R&D or technology development and industry liaison offices. Respondents rated the overall status of their universities on a 5-point Likert scale (from 1 = highly inappropriate to 5 = strongly appropriate). From the 163 directors surveyed, 146 complete and useable questionnaires were returned (response rate = 89.6%). Of the 146 universities rated, 49 were public and 97 were private.

Second, this study used the UIC database to extract data on the governmental funding, industrial funding, and innovation performance of the 146 universities from 2008 to 2011. The development of this database was supported by a research grant from the Ministry of Education of Taiwan, which annually investigates the performance of universities engaged in UIC. Table 1 presents the descriptive statistics for the funding sources and innovation performance of the 146 universities. The average amount of governmental funding for UIC was US\$6,327,827, the average amount of governmental funding for UIC infrastructure was US\$671,740, and the average amount of governmental funding for research projects was US\$19,914,384. Regarding industrial funding, the average amount for UIC was US\$3,224,250 and that for UIC infrastructure was US\$268,187. Finally, the descriptive statistics for innovation performance indicated that the average number of licensing patents was 4.88, the average number of issued patents in Taiwan, the U.S., and other countries was 30.57, the average amount of intellectual property-derived income was US\$498,342, and the average number of businesses stationed in the incubation centre was 5.66.

**Table 1.** Descriptive statistics for different funding sources and innovation performance.

Indicator	Mean	Std. dev.	Min	Max
<i>Governmental funding</i>				
The amount of governmental funding for UIC	6,327,827	565,348,256	0.0	147,641,009
The amount of governmental funding for UIC infrastructure	671,740	40,943,753	0.0	9,323,566.75
The amount of governmental funding for research projects	19,914,384	1,751,418,032	5000.0	522,990,425
<i>Industrial funding</i>				
The amount of industrial funding for UIC	3,224,250	179,829,763	0.0	38,960,188.9
The amount of industrial funding for UIC infrastructure	268,187	45,546,172	0.0	15,507,390
<i>Innovation performance</i>				
The number of licensing patents (exploitation rights granted by licensors to licensees)	4.88	16.00	0.0	118
The number of issued patents in Taiwan, the United States, or other countries	30.57	65.15359	0	403
The amount of intellectual property-derived income	498,342	51,825,777	0.0	13,420,366
The number of business stationed in the incubation centre	5.66	6.31	0.0	40

Source: UIC database 2008–2011.



In this database, we observed that each indicator related to the funding sources and innovation performance was highly skewed. The exponential shape indicated that the majority of funding sources is allocated to only a few universities. This study included universities with industry and government construct indicators that are relatively active simultaneously. Therefore, indicators were first normalised through Z transformation to reduce the dynamic range and to avoid the problem of scale dominance. Subsequently, the Z scores were retransformed using the log-sigmoid function; the numbers of relatively high and low values approached one and zero, respectively, after being repressed. Finally, the Rosin thresholding method, adopted from image processing, was used to automatically determine a corner point of the exponential histogram for each indicator. This process preserved dominant samples and filtered out weak samples (Perng and Chen 2011).

### 3.3. Instruments

This study employed six constructs: governmental funding, industrial funding, UIC management mechanism, UIC regulation implementation, innovation climate, and innovation performance. The definitions and measurements of these instruments are presented in Table 2. We conducted SEM by using PLS to verify the validity and reliability of the instruments. Table 2 indicates that all factor loading values were greater than 0.4 and the *t* value of each indicator exceeded 1.96, indicating that all the dimensions and measurement items exhibited adequate reliability on their latent constructs and no indicators had to be eliminated from the constructs. Convergent validity was assessed by examining composite reliability and average variance extracted (AVE) by construct. Composite reliability had to be greater than 0.7 (Fornell and Larcker 1981) and AVE had to be greater than 0.5 (Diamantopoulos and Siguaw 2000). Table 2 suggests that all the constructs exhibited adequate convergent validity, as evidenced by their AVE and composite reliability scores. Thus, the results

**Table 2.** Factor loading, composite reliability, and average variance extracted of constructs.

Constructs	Measurement items	Factor loading	<i>T</i> -value	Composite reliability	AVE
Governmental funding	The amount of governmental funding for UIC (2008–2011)	0.89	43.99***	0.75	0.61
	The amount of governmental funding for UIC infrastructure (2008–2011)	0.86	52.15***		
	The amount of governmental funding for research projects (2008–2011)	0.84	32.49***		
Industrial funding	The amount of industrial funding for UIC	0.94	58.76***	0.90	0.75
	The amount of industrial funding for UIC infrastructure	0.58	6.80***		
UIC management mechanism	The number of employees engaged in UIC	0.69	14.31***	0.78	0.64
	The number of staff engaged in UIC linkages	0.91	43.32***		
UIC regulation implementation	The extent of rules and regulations for effectively implementing UIC related activities	0.70	15.96***	0.75	0.52
	The appropriateness of achievement distribution in UIC for encouraging teachers and students to join in UIC	0.73	12.29***		
	The appropriateness of intellectual property (technology transfer) income planning for encouraging teachers to engage in technology transfer activities	0.68	12.37***		
	The number of UIC forums held	0.76	17.62***		
Innovation climate	The number of forums or contests held related to entrepreneurship	0.84	24.08***	0.85	0.65
	The number of intellectual property courses offered	0.82	24.44***		
Innovation performance	The number of licensing patents (exploitation rights granted by licensors to licensees) (2008–2011)	0.73	13.71***	0.90	0.69
	The number of issued patents in Taiwan, the United States, or other countries (2008–2011)	0.92	88.42***		
	The total amount of intellectual property-derived income (2008–2011)	0.88	28.89***		
	The number of business stationed in the incubation centre (2008–2011)	0.77	26.17***		

Note: UIC = university-industry collaboration.

\* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ .

suggest that our measurement items possessed sufficient psychometric properties to support the subsequent test of the structural model. The indicators sufficiently represented the corresponding constructs.

#### 4. Results

We tested hypotheses using the PLS-SEM approach because it does not require a large sample (Jung, Chow, and Wu 2003). Before testing the structural model, we examined construct collinearity among variables. We conducted a PLS regression by using the ordinary least squares technique to estimate path coefficients in the structural model, which may generate biased path coefficients if the estimation involves a significant level of collinearity among the predictor constructs. We examined construct collinearity among governmental funding, industrial funding, the UIC management mechanism, UIC regulation implementation, and the innovation climate. Results of the analyses revealed that all the variance inflation factor values were evidently lower than the threshold of 5 (2.03–3.87), indicating that construct collinearity was not a significant problem in our study. Subsequently, a bootstrapping technique with a path weighting scheme and 300 resamples was performed to obtain the estimates of standard errors for testing the significance of path coefficients by using the *t*-test (Chin 1998).

Next, we examined the coefficients of the casual relationship between variables. The coefficients, their *t* value on the structural model, and the explained variance ( $R^2$ ) for each dependent construct are shown in Table 3. The findings from the tested hypotheses were as follows. First, governmental funding positively affected UIC management mechanism ( $\beta = .27, p < .001$ ) and UIC regulation implementation ( $\beta = .42, p < .001$ ) but did not significantly affect the innovation climate ( $\beta = .08, n.s.$ ). Thus, H1 and H4 were supported but H7 was rejected. Second, industrial funding positively affected UIC management mechanism ( $\beta = .46, p < .001$ ), UIC regulation implementation ( $\beta = .22, p < .05$ ), and innovation climate ( $\beta = .31, p < .001$ ). The results thus supported H2, H5, and H8. Third, both UIC management mechanism ( $\beta = .49, p < .001$ ) and UIC regulation implementation ( $\beta = .32, p < .001$ ) positively affected innovation performance but innovation climate did not significantly affect innovation performance ( $\beta = .02, n.s.$ ). Therefore, H3 and H6 were supported but H9 was rejected. Finally, these results revealed that both government and industry facilitated UIC management mechanism and UIC regulation implementation, which in turn influenced university innovation performance.

#### 5. Discussion and conclusion

By using organisational control theory as a theoretical lens, we investigated whether different funding sources (i.e. government or industry) influenced different control mechanisms and subsequently influenced the innovation performance of universities. Findings based on 146 Taiwanese universities provided support for our expectations that both government and industry facilitate

**Table 3.** PLS results tested hypotheses.

Hypothesis	$\beta$	<i>t</i> -value	Results
H1: Governmental funding → UIC management mechanism	0.27	3.32***	Supported
H2: Industrial funding → UIC management mechanism	0.46	6.22***	Supported
H3: UIC management mechanism → Innovation performance	0.49	6.92***	Supported
H4: Governmental funding → UIC regulation implementation	0.42	5.49***	Supported
H5: Industrial funding → UIC regulation implementation	0.22	2.03*	Supported
H6: UIC regulation implementation → Innovation performance	0.32	3.95***	Supported
H7: Governmental funding → Innovation climate	0.08	1.10	Rejected
H8: Industrial funding → Innovation climate	0.31	4.16***	Supported
H9: Innovation climate → Innovation performance	0.02	0.72	Rejected

Note: UIC = university-industry collaboration; UIC management mechanism  $R^2 = 0.48$ ; UIC regulation implementation  $R^2 = 0.37$ ; Innovation Climate  $R^2 = 0.15$ ; Innovation performance  $R^2 = 0.53$ .

\* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ .

UIC management mechanisms and UIC regulation implementation and subsequently influenced innovation performance. Moreover, only industrial funding had a positive effect on innovation climate. We articulate implications for theory and practice as follows.

### **5.1. Implications for theory**

Prior literature has suggested that UIC funding is a major source of income related to improvement of university research outcomes (Goldfarb 2008; Gulbrandsen and Smeby 2005; Huang et al. 2005); however, limited research has focused on whether and how different funding sources (i.e. government or industry) influence different control mechanisms (i.e. UIC management mechanism, UIC regulation implementation, and innovation climate) and university innovation performance. Therefore, this study contributes to the literature in several ways.

First, we found that governmental funding positively affects the UIC management mechanism and UIC regulation implementation, which subsequently influenced innovation performance of universities. The results are consistent with Huang et al. (2005) and Goldfarb's (2008) findings that there is a positive relationship between governmental subsidised funding and innovation outcomes of universities. Our results further contribute to the literature by showing that governmental funding influences innovation performance of universities through UIC management mechanism and UIC regulation implementation.

Second, we found that industrial funding positively affected three types of control mechanisms: UIC management mechanism, UIC regulation implementation, and innovation climate. Moreover, beyond prior literature, we found that industrial funding positively affects the UIC management mechanism and UIC regulation implementation, which subsequently influences university innovation performance. The results are consistent with findings by Gulbrandsen and Smeby (2005), who suggested that industrial funding is significantly related to academic (e.g. patents) and commercial (e.g. commercial products, establishment of firms, and consulting contracts) outcomes. Our findings also support the proposition that an institutional mechanism can facilitate UIC improvement (Youtie, Libaers, and Bozeman 2006).

Third, by comparing the effects of funding sources on control mechanisms, we found that governmental funding has greater influence on UIC regulation implementation while industrial funding has greater influence on UIC management mechanisms. We view this as a reasonable result given that rules and regulations imposed by universities or the government are the main obstacles for UIC; the main characteristics of such rules and regulations are bureaucratic and inflexible (Shen 2017). We also find the greater influence of industrial funding on the UIC management mechanism to be reasonable. In general, industries require a formalised, routine management mechanism to monitor a collaborative relationship. When industries invest more funding in UIC activities, universities are required to develop a formalised management mechanism to maintain the relationship.

Finally, it is noteworthy that we found that only industrial funding had a positive effect on innovation climate. Industry expectations regarding UIC may be reflected in the specific activities that support innovation and entrepreneurship. One of the purposes of governmental funding is to support the innovation climate within a university, but the government may emphasise comprehensive environment building without focusing only on innovation and entrepreneurship-related activities. Thus, another possible reason for the result is that no adequate indicators are available to completely measure the innovation climate and, therefore, the innovation performance of a university exhibits a nonsignificant effect; more appropriate indicators for the evaluation of innovation climate should be developed.

### **5.2. Implications for practice**

First, our results indicate that both governmental and industrial funding benefit university innovation performance. For increasing funding from different sources, we suggest faculty and administrative

staff develop an entrepreneurship mindset that combines the traditional role of universities with profit seeking (Etzkowitz 1998). Second, we also found that funding facilitates improvements to university structures overall (i.e. control mechanisms). Specifically, governmental funding has greater influence on UIC regulation implementation while industrial funding has greater influences on UIC management mechanism and innovation climate. This implies that universities should strategically choose funding sources. If a university's purpose is to make the organisational structure more flexible, we suggest seeking more government funding; in contrast, if the university's purpose is to create a favourable environment that supports UIC activities, we suggest pursuit of funding from industries. A university is more likely to become an entrepreneurial university through frequent interaction with industries.

### 5.3. Limitations and future research suggestions

This study has several limitations that can be addressed in future research. First, this study is a preliminary step toward understanding the effects of different funding sources on the innovation performance of universities; however, this study was conducted in Taiwan and the results may not be generalisable to other countries. We recommend future research attempt to replicate our research model in other countries. Second, this study measured UIC management mechanism, UIC regulation implementation, and innovation climate with subjective measures. More objective data may enrich our understanding of the relationships between variables. Particularly, we did not find a significant relationship between governmental funding and innovation climate or between innovation climate and innovation performance. One possible explanation for this finding is that we measured innovation climate using proxy variables from existing databases. Because innovation climate plays an important role in innovation literature (Hsu and Fan 2010; Hunter, Bedell, and Mumford 2007), we suggest future research use other measurements of innovation climate and further explore the role of innovation climate in the UIC context.

### Disclosure statement

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