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Public support for business innovation in Mexico: a cross-sectional analysis

Juan L. Martinez-Covarrubias[a], Helena Lenihan[b] and Mark Hart[c]

ABSTRACT

Public support for business innovation in Mexico: a cross-sectional analysis. *Regional Studies*. This paper explores the impact of government support in Mexico on the likelihood of firms achieving functional and/or inter-sectoral upgrading in global value chains (GVCs). Employing a unique dataset, regression analysis was undertaken to estimate the predicted probabilities of firms upgrading in GVCs considering their regional location. The results suggest that firms located in Mexico City are more likely to achieve functional upgrading vis-à-vis northern firms. Additionally, the presence of a research and development laboratory is crucial if firms are to engage in upgrading. There was no evidence that government support affects the likelihood of firms achieving functional and/or inter-sectoral upgrading.

KEYWORDS

business innovation policy; developing countries; upgrading in global value chains; dual-control-group analysis; regional heterogeneity

摘要

墨西哥商业创新的公共支持：跨部门分析。区域研究。本文探讨墨西哥政府的支持，对于厂商在全球价值链（GVCs）中取得功能和／或跨部门升级的可能性之影响。本文运用一组特别的数据集进行迴归分析，考量厂商的区域位置后，评估其预计于GVCs中升级的可能性。研究结果显示，位于墨西哥市的厂商，较北部的厂商更可能获得功能升级。此外，若厂商想参与升级的话，研发实验室的存在相当关键。我们并未发现证据能够证明，政府支持对于厂商取得功能和／或跨部门升级的可能性有所影响。

关键词

商业创新政策; 发展中国家; 在全球价值链中升级; 双重控制组分析; 区域异质性

RÉSUMÉ

Le soutien gouvernemental en faveur de l'innovation en entreprise au Mexique: une analyse transversale. *Regional Studies*. Ce présent article examine l'impact du soutien gouvernemental au Mexique sur la possibilité que les entreprises réalisent une mise à niveau fonctionnelle et/ou intersectorielle aux chaînes de valeur mondiales. Employant un ensemble de données original, une analyse de régression est faite pour estimer la probabilité que les entreprises qui modernisent leurs chaînes de valeur mondiales remettent en question leur localisation régionale. Les résultats laissent supposer que les entreprises situées à Mexico sont plus susceptibles de réaliser une mise à niveau fonctionnelle par rapport aux entreprises du nord. En outre, la présence d'un laboratoire de recherche et de développement est essentielle si les entreprises sont à investir dans la mise à niveau. Rien ne prouve que le soutien gouvernemental influence la possibilité que les entreprises réalisent une mise à niveau fonctionnelle et/ou intersectorielle.

MOTS-CLÉS

politique en faveur de l'innovation en entreprise; pays en voie de développement; mise à niveaux aux chaînes de valeur mondiales; analyse par groupe témoin double; hétérogénéité régionale

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ZUSAMMENFASSUNG

Öffentliche Subventionen für geschäftliche Innovation in Mexiko: eine sektorenübergreifende Analyse. *Regional Studies*. In diesem Beitrag untersuchen wir die Auswirkung von staatlichen Subventionen in Mexiko auf die Wahrscheinlichkeit, dass Firmen in globalen Wertschöpfungsketten eine funktionelle und/oder sektorenübergreifende Verbesserung erreichen. Mithilfe eines eindeutigen Datensatzes wird eine Regressionsanalyse durchgeführt, um die prognostizierten Wahrscheinlichkeiten einer Verbesserung von Firmen in globalen Wertschöpfungsketten unter Berücksichtigung ihres regionalen Standorts abzuschätzen. Aus den Ergebnissen geht hervor, dass Firmen in Mexiko-Stadt eher eine funktionelle Verbesserung erreichen als Firmen im Norden. Darüber hinaus ist die Präsenz eines Forschungs- und Entwicklungslabors für die Verbesserung der Firmen von entscheidender Bedeutung. Es liegen keine Anzeichen dafür vor, dass sich staatliche Subventionen auf die Wahrscheinlichkeit auswirken, dass Firmen eine funktionelle und/oder sektorenübergreifende Verbesserung erreichen.

SCHLÜSSELWÖRTER

Geschäftsinnovationspolitik; Entwicklungsländer; Verbesserung in globalen Wertschöpfungsketten; duale Kontrollgruppenanalyse; regionale Heterogenität

RESUMEN

Apoyo público para la innovación empresarial en México: un análisis transversal. *Regional Studies*. En este artículo analizamos qué efecto tienen los apoyos gubernamentales en México para que las empresas tengan más posibilidades de lograr una mejora funcional y/o intersectorial en las cadenas globales de valor. A partir de una base de datos propia, llevamos a cabo un análisis de regresión para calcular las probabilidades de mejora de las empresas en las cadenas globales de valor tomando en consideración su ubicación regional. Los resultados indican que las empresas ubicadas en la ciudad de México tienen más probabilidades de conseguir mejoras funcionales en comparación con las empresas del norte. Asimismo la presencia de un laboratorio de investigación y desarrollo en las empresas es fundamental para asegurar dichas mejoras. No hay indicios de que el apoyo gubernamental afecte significativamente a la probabilidad de que las empresas consigan mejoras funcionales y/o intersectoriales.

PALABRAS CLAVES

política de innovación empresarial; países en desarrollo; mejoras en las cadenas globales de valor; análisis de grupo de control dual; heterogeneidad regional

JEL L52, O31, R12, R58

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INTRODUCTION

The United Nations Conference on Trade and Development (UNCTAD) (2011) and the Organisation for Economic Co-operation and Development (OECD) (Gurría, 2012) are increasingly debating the topics of innovation and ways to upgrade global value chains (GVCs) in the context of developing countries. However, these institutions have not developed methods that accurately evaluate the impact of government innovation interventions (policy instruments) with particular focus on their effectiveness in helping firms to upgrade in GVCs. This may reflect the fact that the literature on innovation policy evaluation (Todd & Wolpin, 2010) has fallen short in considering the impact of government innovation interventions on the likelihood of firms achieving functional or inter-sectoral upgrading, and the extent to which this varies by region. Assessing the performance and impact of these policy instruments is important for maintaining accountability (Lenihan, 2011) and to enable policy-makers to ensure that future interventions are appropriate, effective and efficient (Niosi, 2010).

This paper suggests that the optimum policy design needs to take the regional context into account. Yet the concept of a region is ambiguous. Given the globalization process, the concept of a region relates to a vague notion in which a region is a fraction of the whole (Meixueiro-Najera, Moreno-Perez, & Martin-Lopez, 2012). The objective of this paper is to investigate empirically the factors that impact upon the likelihood of firms achieving functional and/or inter-sectoral upgrading, explicitly incorporating government support for business innovation[1] and testing for regional differences when firms upgrade in GVCs.

The results suggest that regional context significantly affects the likelihood of firms to upgrade in GVCs, with firms located in Mexico City more likely to upgrade vis-à-vis firms located in the north of the country. Another significant factor to upgrade is the presence of a research and development (R&D) laboratory. Surprisingly, there is no evidence that government support makes a difference when upgrading in GVCs. This paper makes both theoretical and policy-based contributions. Thorough research indicates this is the first time that: (1) the likelihood to upgrade in GVCs is estimated by means of econometric analysis, providing insights to the policy-making community to better design future instruments; and (2) regional heterogeneity to upgrade in GVCs in Mexico has been tested, proving that region matters.

The paper is structured as follows. The second section presents a review of the literature on GVCs with a particular focus on the importance of firms upgrading in developing countries, the impact of regional location and government intervention. Additionally, it sets out the hypotheses to be tested. The third section presents methods and data issues. The fourth section includes the estimation results from the econometric analysis with a view to identifying causal relationships posed in the hypotheses. Findings, policy implications and study limitations are presented in the fifth section. The results provide evidence supporting the development of theory in the areas of GVCs, innovation, and regional studies. Policy design should consider that a range of factors may affect the scale of innovation activities in different regions. Conclusions and avenues for future research are presented in the sixth section.

UPGRADING IN GLOBAL VALUE CHAINS, REGIONAL LOCATION AND GOVERNMENT INTERVENTION

The literature on GVCs, the role of regions in terms of economic performance and on the rationale for government intervention are invoked.

Global value chains (GVCs)

According to Pietrobelli and Rabellotti (2006), a firm's environment is shaped, first, by the collective efficiency of the cluster in which the firm operates, second, by the pattern of governance of the value chain and, third, by the sectoral dimension related to peculiar joint features that characterize learning and upgrading patterns. Building on Humphrey and Schmitz's (2000) contribution, Pietrobelli and Rabellotti (2006) recognized four types of upgrading for firms: process, product, functional and inter-sectoral. The third and fourth types of upgrading have particular importance in terms of improving a firm's position within GVCs. *Functional upgrading* is the acquisition of new, superior functions in the value chain (such as design or marketing) or the abandonment of lower-value-added functions so that the firm can focus on higher-value-added activities. *Inter-sectoral upgrading*, on the other hand, involves the application of competence acquired in a particular function to move into a new sector, often in superior products or services.

Regional location

There is an increasing literature that tests regional differences when analysing upgrading in GVCs (e.g., Pavlínek & Ženka, 2011), however, to date such studies have not concerned themselves with the Mexican case. Given the 'maquila' phenomenon,[2] it is important to bear in mind that firms located in the north[3] of the country are more likely to be embedded in GVCs with a hierarchical and quasi-hierarchical governance pattern vis-à-vis firms located in the centre and south, where GVCs are more likely to exhibit a network or market governance pattern. If this is the case, then it would be reasonable to expect that businesses located in the northern region are less likely to achieve functional and/or inter-sectoral upgrading vis-à-vis central and southern firms, as predicted by Humphrey and Schmitz (2002). These central and southern firms would be more likely to achieve these type of upgrading given their ease of access to alternative markets (outside the United States and Canada), such as the national market and the rest of Latin America. Having said this, it is reasonable to expect that some variables affecting the likelihood of firms upgrading in GVCs (which will be explained below) may have different effects in different regions of the country.

This study incorporates a spatial dimension regarding the study of GVCs as suggested by Fold (2014). In this vein, Mexico has very high inter-regional disparities in income levels and productivity. For instance, Chávez and Fonseca (2012) found differences in the level of technological development, measured in terms of structural efficiency, between the northern and central regions as compared with the south that partially explains the labour productivity gap among regions. This can be explained by means of the effects of trade liberalization that Mexico engaged in over the last three decades. Major trade reforms introduced in 1985 and 1994 have had a profound effect on the difference of performance in relative employment growth and relative efficiency among Mexican regions. Chiquiar (2005) provided evidence that Mexico's trade reforms, effected through the North American Free Trade Agreement (NAFTA) with the United States and Canada led to a divergent pattern in internal regional economic performance. Measured in terms of per capita output levels, northern firms in Mexico outperformed central and southern firms. Trade liberalization has increased ties between northern Mexico and the United States; at the same time the ties between northern and southern Mexico have weakened. This can be explained by the role of distance from the border with the United States being an important factor (Hanson, 1998).

Role of government

Given that the national innovation systems of developing countries are underdeveloped, lacking in terms of absorptive capacity, technological capabilities, fertile ecology and robust innovation systems vis-à-vis developed countries (Dutrénit et al., 2010), policies to support these factors are justified. Several evaluations of innovation policies in the Latin American region have taken place, such as those of Hall and Maffioli (2008), yielding interesting insights regarding impacts of government support for business innovation on the standard types of innovation output (i.e., product, process, marketing and organizational), in line with the Oslo Manual (OECD, 2005). However, they fall short in measuring the type of innovation suggested by Pietrobelli and Rabellotti (2006) that are crucial for developing countries. This paper aims to fill this gap.

If prospects for development are a priority in the design of business innovation policies, then policy-makers in

developing countries should be concerned about the likelihood that functional and/or inter-sectoral upgrading will occur. International organizations, such as UNCTAD and the OECD, are increasingly exploring innovation and upgrading in GVCs in the context of developing countries. Assuming that policy-makers in developing countries follow the lead of these international organizations, it becomes important to consider the context-specific factors in developing country regions. In Latin America, such factors include the low propensity to undertake R&D activities in-house (Archibugi & Pietrobelli, 2003), the absence of linkages between firms and universities and weak local knowledge dissemination networks (Cimoli & Katz, 2002), and the withdrawal from engineering-intensive industries that results from specialization in resource-based sectors (Huang & Miozzo, 2004).

The central theoretical arguments that shape this research are, first, functional and inter-sectoral upgrading in GVCs are the type of innovation required by developing countries, as they offer opportunities for firms to compete successfully in the global economy. Therefore, it is necessary to explore the factors affecting the likelihood of firms upgrading in GVCs. Second, differences in regional characteristics and economic performance are important when designing policy interventions. Regional features should inform policies, such as the availability of a specialized labour market, local inputs, and ease of access to markets and market information. Third, given the role of government in promoting innovation, it is paramount to determine the impact of government policy in terms of firms upgrading in GVCs. These three central arguments of the theoretical underpinnings previously discussed shape the research question and the following hypotheses:

Hypothesis 1. The likelihood that a firm will functionally and/or inter-sectorally upgrade in GVCs depends on four dimensions:

Hypothesis 1a: Cluster collective efficiency, defined as the competitive advantage derived from local external economies and joint action.

Hypothesis 1b: Governance pattern of GVCs, which is the type of coordination required to decide what, how and how much is to be produced in the value chain.

Hypothesis 1c: The sector in which the firm operates, which relates to the distinctive patterns of learning and innovation by economic sectors.

Hypothesis 1d: The regional location. Firms located in the north region are less likely functionally and/or inter-sectorally to upgrade in GVCs as compared with firms in the centre and south of Mexico.

The main expectation is that these variables are statistically significant. (The sign expectation for each variable is presented in Table 1.):

Hypothesis 2: Government support for business innovation in Mexico in the period 2006–09 increases the likelihood that firms will functionally and/or inter-sectorally upgrade in GVCs.

METHODS

This paper adopts a quantitative (regression analysis) approach to investigate causal relationships related to the likelihood of firms upgrading in GVCs. The evaluative framework developed represents current 'best' practice, as advocated by Fritsch and Storey (2014). It is important to bear in mind that the qualitative approach carried out by Pietrobelli and Rabellotti (2006) was able to show how a firm or group of firms produced perceived upgrading within its GVC. Indeed, the comprehensive analysis conducted by these authors enabled the operationalization of the variables for upgrading and clustering by formulating questions and scenarios based on the definitions identified by them.

The evaluation framework adopted here comprises a cross-sectional analysis for the period 2006–09[4] and employs a two-step Heckman (1979) selection model.[5]

Modelling upgrading in GVCs

Given the nature of the data collection, an issue looked at in more detail below, sampling bias may arise due to self-selection of our 'treated' respondents. To account for this potential problem, the following two-step Heckman selection model (Heckman, 1979) is adopted, as proposed by Hart, Driffield, Roper, and Mole (2008) and Greene (2014).

A bi-probit Heckman approach (Greene, 2014) is used, where a recursive model is simultaneously estimated for two equations: selection and structural (Savignac, 2008)[6] to measure the likelihood of firms achieving functional and/or inter-sectoral upgrading in GVCs.

In the first stage, the so-called selection equation (equation 1), a probit model is estimated that calculates the probability that a firm will receive government support for business innovation (a dummy that takes a value of 1 if the firm has received public support in the period 2006–09; and 0 otherwise). In this analysis the same regressors of the structural equation are included, plus the dummy political affinity to address the identification problem, which is explained below.

The selection equation:

$$\begin{aligned} \Pr([F_i]|z_i) &= \Phi(\eta_i^*) \\ \eta_i^* &= z_i\Theta + M_{si} \end{aligned} \tag{1}$$

The second stage – the estimate of the structural equation (equation 2) – focuses on firms that have achieved functional and/or inter-sectoral upgrading in GVCs but controls for possible sample selection bias by incorporating an additional explanatory variable, the so-called inverse Mill's ratio (IMR).

The structural equation:

$$\begin{aligned} \Pr([F{:}I_i]|x_i) &= \Phi(\eta_i) \\ \eta_i &= x_i\Lambda + M_{oi} \end{aligned} \tag{2}$$

The dependent variables in the structural equation (equation 2) are dichotomous: the value 1 is taken if either

Table 1. Variable descriptives.

Variable	Description	Expected sign
Dependent		
Type of upgrading in global value chains	1 = functional upgrading; 0 = otherwise	
	1 = inter-sectoral upgrading; 0 = otherwise	
Explanatory		
Business age (reference category: < 5 years)	1 = 5–9 years; 0 = otherwise	(–)
	1 = > 10 years; 0 = otherwise	(–)
Ownership	1 = indigenous; 0 = foreign owned	(+)
R&D employment[a]	R&D employees/total number of employees in 2009	(+)
R&D laboratory	1 = have R&D laboratory; 0 = otherwise	(+)
R&D department	1 = formal R&D department; 0 = otherwise	(+)
Size	Total number of employees in 2009 in logs	(+)
Structure (reference category: Independent firm)	1 = firm with subsidiaries; 0 = otherwise	(+)
	1 = subsidiary of another firm; 0 = otherwise	(–)
	1 = venture business; 0 = otherwise	(+)
Exporter	1 = yes; 0 = otherwise	(+)
Sector (reference category: Traditional manufacturing)	1 = natural resource based; 0 = otherwise	(–)
	1 = complex products; 0 = otherwise	(+)
	1 = specialized suppliers; 0 = otherwise	(+)
Governance pattern in global value chain (GVC) (reference category: Hierarchical)	1 = networking; 0 = otherwise	(+)
	1 = quasi-hierarchical; 0 = otherwise	(–)
	1 = market; 0 = otherwise	(+)
External economies clustering (reference category: No availability)	1 = specialized labour market availability; 0 = otherwise	(+)
	1 = local inputs available; 0 = otherwise	(+)
	1 = ease of information and markets; 0 = otherwise	(+)
R&D linkages	1 = yes; 0 = otherwise	(+)
R&D investment[b]	R&D investment/total turnover in 2009	(+)
Government support	1 = recipient; 0 = otherwise	(+)
Region (reference category: North)	1 = Centre (except Mexico City); 0 = otherwise	(+)
	1 = Mexico City; 0 = otherwise	(+)
	1 = South; 0 = otherwise	(+)

Notes: [a]This variable was constructed as a relative measure to enable it to be continuous. In an initial stage when collecting data, there was a trade-off between accuracy of responses and response rate. After administering the survey, the only data available for this variable were in ordinal form, with three bins: (1) 1–4 employees in R&D; (2) 5–9 employees in R&D; and (3) more than 10 employees dedicated to R&D. However, in order to allow it to be continuous, it was constructed as a relative measure in terms of the total employees of the firm.
[b]The same applies: R&D investment, which was constructed as a relative measure in terms of total turnover of the firm. North region comprises the states of Baja California Norte, Baja California Sur, Sonora, Chihuahua, Sinaloa, Durango, Coahuila, Nuevo Leon, Zacatecas, San Luis Potosi, Tamaulipas and Nayarit. Centre (except Mexico City) region comprises of Aguascalientes, Jalisco, Guanajuato, Queretaro, Hidalgo, Colima, Michoacán, Morelos, Tlaxcala, Puebla and Veracruz. Mexico City comprises Distrito Federal and Estado de Mexico. South region: Guerrero, Oaxaca, Chiapas, Tabasco, Campeche, Yucatan and Quintana Roo.

functional and/or inter-sectoral upgrading is achieved; 0 otherwise. The measurement of these dependent variables is based on the self-assessment responses from interviewed managing directors of firms that responded to the survey. The independent variable, denoted as x_i in equation (2), represents the vector of 15 explanatory variables (Table 1).

Relevant variables for evaluating public support for business innovation impact in developing countries can be identified using the prevailing evaluation literature (O'Regan, Ghobadian, & Sims, 2006). The contributions of Gereffi (2014) also enable a better identification of the relevant variables in the model, reducing the number of control variables (Table 1) to determine the likelihood of upgrading in GVCs in the Mexican context over the period 2006–09.

These variables are the age of the firm; ownership (indigenous versus foreign-owned firm); absorptive capacities (R&D employment, relative measure in terms of total employment, thus specifying it as a continuous variable); technological capabilities (R&D laboratory and formal R&D department); firm size; firm structure; whether or not the firm exports; sector; governance pattern in

GVCs; external economies of clustering;[7] R&D linkages;[8] level of annual R&D investment[9] (relative measure in terms of total turnover), and the region where the firm is located. In equation (2), vector x_i includes a binary variable representing government support for business innovation – it takes the value 1 if a firm received support; and 0 otherwise.

The vector z_i in equation (1) includes same variables, except government support for business innovation, which is considered the dependent variable. The identification problem is addressed by including 'political affinity' as an instrumental variable (Nieto, 2011). This is a binary variable taking the value of 1 if the political party in power of local government (where the firm operates) is the same political party in power of the federal government (who actually allocates the government support for business innovation); 0 otherwise. This variable is used as a proxy for 'political clientelism', which is defined as 'the distribution of resources by politicians in exchange for support' (Montero, 2010, p. 116). This variable is expected to affect the probability of receiving government support for business innovation and not necessarily affect innovative output.

Data and characteristics of the sample

A unique dataset comprising business performance and innovation measures during the period 2006–09 for 477 firms in Mexico was collected. Although the aim was to achieve a randomly defined sample, programme-selection bias was latent; however, the two-step Heckman selection model detailed above is designed to address this problem. The sample was extracted from the Mexican National Register of Scientific and Technological Institutes and Enterprises, known as RENIECYT (CONACYT, 2011), and the Mexican Entrepreneurial Information System (SIEM, 2015). RENIECYT (SIICYT, 2011)[10] comprises all firms and entities that have applied on at least one occasion for public financial support for business innovation. It includes recipients (successful applicants) of government support[11] as well as non-recipients (unsuccessful applicants) with similar characteristics. From the sample, 164 firms are recipients (successful applicants during 2006–09). To achieve the most accurate insights regarding the effect of government support, two control groups (non-recipients) were constructed: the first comprised 157 unsuccessful applicants[12] for support during 2006–09; the second comprised 156 non-applicants identified from the official record for businesses in Mexico (SIEM), which comprises all firms operating in Mexico.[13] Random sampling selection was performed to gather data on R&D and innovation activities and impacts of interest through the survey. The second control group (non-applicants) was carefully built to match the characteristics of recipients in terms of location, sector and firm size.

A telephone survey was performed, with an overall response rate of 20%: from the 2385 firms contacted, 477 agreed to be interviewed. During data collection, more than 80% of respondents could not provide details on the specific type of government support for business innovation they had received. As a result, a general/aggregate measure for business innovation policy instruments (i.e., government support) was used, and therefore the various instrument types could not be distinguished, which is a limitation of the current study.

ESTIMATION RESULTS

The dual-control-group approach addresses the difference in effects between innovation willing firms (recipients-control group 1) versus innovation non-willing firms (recipients versus control group 2), and it is in line with Savignac's (2008) approach to address potential problems of endogeneity of obstacles and propensity to innovate.

Dual-control-group analysis

Table 2 presents descriptive statistics of recipients and non-recipients by functional upgrading, inter-sectoral upgrading, and the critical variables used in the regressions presented in Tables 4 and 5. Although there are no statistical differences between the two types of upgrading, it is noteworthy that recipients show an average functional upgrading of 68% in the period 2006–09, while the mean for unsuccessful applicants (control group 1) is 64% in the same period. Nevertheless, non-applicants (control group 2) show an average (66%) higher than that of unsuccessful applicants. Interestingly, in terms of inter-sectoral upgrading, the results are mixed. When comparing recipients and control group 1 (unsuccessful applicants), more recipients (42%) seem to achieve this type of upgrading than do unsuccessful applicants (35%). However, when comparing recipients and the second control group (non-applicants), it seems that more non-applicants (48%) achieve inter-sectoral upgrading than do recipients (42%). There is no statistical difference among the three groups with regards to the two types of upgrading. The only statistical difference can be observed between the two control groups in terms of inter-sectoral upgrading. It is interesting to observe that for all groups, functional upgrading is more frequent (64–68%) than inter-sectoral upgrading (35–48%).

As evidenced in Table 2, statistical differences between recipients and both control groups can be observed in terms of nine variables: R&D employment, R&D laboratory, R&D department, size, structure, exporter, external economies of clustering regarding ease of information and markets, R&D linkages, and R&D investment. Of particular interest vis-à-vis hypothesis 1 is the fact that control group 1 is statistically different from control group 2 in terms of inter-sectoral upgrading and R&D department. Specifically, 40% of unsuccessful applicants have an R&D department, while only 28% of non-applicants have this kind of facility. Table 3 exhibits the regional differences identified from the survey data. When conducting significance tests, these regional differences are noticeable in terms of functional upgrading, inter-sectoral upgrading, R&D laboratory, R&D department, exporter, governance pattern in GVC, external economies of clustering with specialized labour market availability and ease of information and markets, and R&D linkages. The results

Table 2. Summary statistics: recipients (successful applicants) versus control group 1 (unsuccessful applicants) and control group 2 (non-applicants).

	Recipients: 164 (a)		Control Group 1: 157 (b)			Control Group 2: 156 (c)			
Variable	**Mean**	**SD**	**Mean**	**SD**	**Significance test (a) and (b)**	**Mean**	**SD**	**Significance test (a) and (c)**	**Significance test (b) and (c)**
Functional upgrading	0.687	0.465	0.643	0.482	$t = –0.728$	0.667	0.516	$t = –0.360$	$t = 0.3649$
Inter-sectoral upgrading	0.423	0.532	0.357	0.596	$t = –0.903$	0.489	0.543	$t = 1.068$	$t = 1.748$*
Business age	2.409	0.828	2.274	0.844	$t = –1.442$	2.410	0.769	$t = 0.0193$	$t = 1.4937$
Ownership	1.201	0.510	1.217	0.570	$t = 0.253$	1.212	0.568	$t = 0.1707$	$t = –0.0781$
R&D employment	0.088	0.505	0.002	0.518	$t = –1.5052$*	0.003	0.520	$t = –1.4822$*	$t = 0.0170$
R&D laboratory	0.552	0.499	0.337	0.475	$t = –3.481$***	0.394	0.490	$t = –2.780$***	$t = 0.9116$
R&D department	0.429	0.497	0.408	0.494	$t = –0.3364$	0.289	0.455	$t = –2.5825$**	$t = –1.901$*
Size (number of employees in 2009 in logs)	4.222	2.093	3.619	1.668	$t = –2.860$***	3.858	1.715	$t = –1.7050$*	$t = 1.2507$
Structure	1.738	1.056	1.490	0.917	$t = –2.2435$**	1.619	1.021	$t = –1.0186$	$t = 1.1727$
Exporter	0.503	0.502	0.400	0.492	$t = –1.8353$*	0.455	0.500	$t = –0.8627$	$t = 0.9596$
Industrial sector	2.848	1.013	2.955	1.094	$t = 0.9156$	2.801	1.133	$t = –0.3846$	$t = –1.2244$
Governance pattern in global value chain	1.772	1.034	1.809	1.008	$t = 0.3195$	1.870	1.052	$t = 0.8294$	$t = 0.5172$
External economies clustering: specialized labour market availability	0.522	0.501	0.495	0.503	$t = –0.4157$	0.537	0.500	$t = 0.2576$	$t = 0.6264$
External economies clustering: local inputs available	0.472	0.501	0.543	0.501	$t = 1.0874$	0.467	0.501	$t = –0.0779$	$t = –1.1241$
External economies clustering: ease of information and markets	0.734	0.443	0.628	0.486	$t = –1.7380$*	0.617	0.488	$t = –2.1356$**	$t = –0.1695$
R&D linkages	0.739	0.440	0.551	0.500	$t = –3.069$***	0.557	0.499	$t = –3.333$***	$t = 0.0931$
R&D investment	0.086	0.466	0.003	0.498	$t = –1.5402$*	0.002	0.490	$t = –1.579$*	$t = –0.0268$
Region	2.032	0.816	2.124	0.725	$t = –0.243$	2.046	0.747	$t = –0.425$	$t = –0.578$

Note: Significance levels: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$. '(a)' denotes the group of recipients, '(b)' denotes control group 1, and '(c)' denotes control group 2. When carrying out significance tests, these groups (a–c) are compared.

Table 3. Summary statistics: regional differences.

	North (a)		Mexico City (b)			Centre (excluding Mexico City) (c)			South (d)					
Number of firms per region	**143**		**95**			**119**			**120**					
Variable	**Mean**	**SD**	**Mean**	**SD**	**Significance test (a) and (b)**	**Mean**	**SD**	**Significance test (a) and (c)**	**Mean**	**SD**	**Significance test (a) and (d)**	**Significance test (b) and (c)**	**Significance test (b) and (d)**	**Significance test (c) and (d)**
Functional upgrading	0.487	0.455	0.743	0.524	$t = 0.957$**	0.567	0.584	$t = 0.421$	0.433	0.582	$t = -0.385$	$t = -0.925$*	$t = -0.993$*	$t = -0.429$
Inter-sectoral upgrading	0.333	0.548	0.498	0.596	$t = 0.984$*	0.475	0.534	$t = 0.568$	0.320	0.459	$t = -0.432$	$t = -0.482$	$t = -0.948$*	$t = -0.484$
Business age	2.524	0.785	2.858	0.854	$t = 0.365$	2.187	0.698	$t = -0.239$	2.758	0.855	$t = 0.442$	$t = -0.374$	$t = -0.437$	$t = 0.458$
Ownership	1.231	0.511	1.224	0.585	$t = -0.253$	1.222	0.586	$t = -0.171$	1.115	0.569	$t = -0.253$	$t = -0.080$	$t = -0.124$	$t = -0.089$
R&D employment	0.009	0.551	0.081	0.581	$t = 0.505$	0.003	0.532	$t = -0.454$	0.002	0.489	$t = -0.458$	$t = -0.408$	$t = -0.170$	$t = -0.701$
R&D laboratory	0.325	0.504	0.612	0.512	$t = 1.124$**	0.544	0.489	$t = 1.102$*	0.241	0.457	$t = 0.524$	$t = -0.825$*	$t = -0.324$	$t = -0.301$
R&D department	0.404	0.602	0.608	0.794	$t = 0.364$*	0.391	0.525	$t = -0.520$	0.308	0.594	$t = -0.364$	$t = -0.301$	$t = -0.920$**	$t = -0.251$
Size (number of employees in 2009 in logs)	3.485	1.385	3.825	1.498	$t = 0.604$	3.658	1.515	$t = 0.405$	2.921	1.464	$t = -0.660$	$t = -0.357$	$t = -1.102$	$t = -1.257$
Structure	1.521	1.166	1.328	0.958	$t = -0.359$	1.648	1.142	$t = -0.568$	1.522	0.954	$t = -0.413$	$t = 0.371$	$t = 0.424$	$t = 0.302$
Exporter	0.631	0.428	0.490	0.592	$t = -0.533$	0.413	0.607	$t = -0.842$	0.400	0.592	$t = -1.837$*	$t = 0.545$	$t = 0.596$	$t = 0.458$
Industrial sector	2.844	1.012	2.957	1.091	$t = 0.516$	2.811	1.134	$t = -0.385$	2.956	1.093	$t = 0.516$	$t = -0.423$	$t = -0.443$	$t = -0.423$
Governance pattern in global value chain	2.902	1.134	1.929	0.988	$t = -1.315$**	1.871	1.153	$t = 0.941$*	1.819	1.214	$t = -0.951$*	$t = -0.512$	$t = -0.417$	$t = -0.412$
External economies clustering: specialised labour market availability	0.494	0.668	0.598	0.618	$t = 0.970$**	0.538	0.612	$t = 0.371$	0.395	0.713	$t = -0.415$	$t = -0.424$	$t = -0.824$*	$t = -0.346$
External economies clustering: local inputs available	0.456	0.527	0.545	0.602	$t = 0.445$	0.468	0.552	$t = 0.479$	0.543	0.618	$t = 0.524$	$t = -0.523$	$t = -0.124$	$t = 0.418$
External economies clustering: ease of information and markets	0.734	0.743	0.628	0.686	$t = -0.538$	0.617	0.688	$t = -0.139$	0.528	0.686	$t = -1.638$*	$t = -0.325$	$t = -1.169$*	$t = -0.958$*
R&D linkages	0.539	0.641	0.591	0.603	$t = 0.475$	0.518	0.679	$t = -0.433$	0.351	0.612	$t = -0.897$*	$t = -0.398$	$t = -0.931$*	$t = -0.954$*
R&D investment	0.030	0.666	0.025	0.698	$t = -0.542$	0.022	0.590	$t = -0.579$	0.021	0.688	$t = -0.543$	$t = -0.368$	$t = -0.468$	$t = -0.382$
Government support for business innovation	0.502	0.612	0.495	0.617	$t = -0.415$	0.537	0.614	$t = 0.576$	0.491	0.603	$t = -0.417$	$t = 0.464$	$t = -0.348$	$t = -0.482$

Note: Significance levels: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$. '(a)' denotes the group of firms located in the North; '(b)' denotes the group of firms located in Mexico City; '(c)' denotes the group of firms located in the centre, except Mexico City; and '(d)' denoted the group of firms located in the South. When carrying out significance tests, these groups (a–d) are compared.

suggest that firms located in Mexico City differ to firms located in the north with respect of functional upgrading, inter-sectoral upgrading, R&D laboratory or R&D department. It seems that firms located in the north tend to operate in GVCs with hierarchical and/or quasi-hierarchical governance patterns vis-à-vis firms located in the rest of the country. The latter appear to operate mainly in GVCs with market or networking governance patterns. In general terms, firms located in the south exhibit weak performance in terms of having R&D laboratories or R&D departments; exporting; external economies of clustering in terms of specialized labour market availability, and ease of information and markets; and R&D linkages vis-à-vis firms located elsewhere in the country. Clear regional differences arise with the south region lagging in terms of economic and innovation activities.

To address the potential problem of selection bias, the two-step Heckman model identified in equations (1) and (2) was performed (on two occasions). The first estimation applies to recipients (successful applicants) and control group 1 (unsuccessful applicants). The second estimation applies to recipients and control group 2 (non-applicants). Considering each control group separately, Table 4 presents the results of the bi-probit model. Heteroskedasticity and collinearity were tested. The results suggest that multicollinearity is not an issue in this model. However, heteroskedasticity is present, so robust standard error estimation is employed.

The estimation results of the selection equation, in the various specifications (columns 3, 7, 11 and 15 in Table 4), found eight statistically significant variables: ownership, R&D employment, R&D department, size, exporter, R&D linkages, R&D investment, and the control variable political affinity. In line with the results presented in Table 4, the average marginal effects of the bi-probit models, with sample selection, are estimated, explaining the factors correlated to the propensity to achieve functional upgrading and inter-sectoral upgrading (Table 5).

Investigating upgrading in GVCs

Table 5 presents the average marginal effects regarding the probability of a recipient achieving functional and/or inter-sectoral upgrading compared with each control group of non-recipients. The results suggest that region (Mexico City versus North, columns 1, 3 and 5), and its combined effect[14] with the presence of a R&D laboratory (columns 1 and 5) and clustering (column 5) affect the likelihood to upgrade in GVCs. In this regard, hypothesis 1d cannot be rejected. In terms of government support, the results suggest that it does not affect the likelihood of firms upgrading functionally or inter-sectorally in GVCs. Despite being included in the structural model, the selection term does not affect the outcome. This result disproves the second hypothesis.

The estimation of the structural model with recipients and the first control group (unsuccessful applicants) reports five statistically significant variables affecting the likelihood of achieving functional upgrading: R&D laboratory, structure, sector, governance pattern in GVCs and region. The average marginal effects reported in Table 5 allow for the discussion of the magnitude of the relationship identified above. The variable with the highest average impact is region, followed by governance pattern in GVCs and R&D laboratory. The combined effects (interactive term 1) of region and having or not an R&D laboratory are more interesting. They show that if the firm with the R&D department is located in Mexico City, its probability to achieve functional upgrading will increase even further. In terms of firm structure, a venture business is less likely to functionally upgrade than an independent firm without subsidiaries. A firm operating in the specialized services sector is less likely to functionally upgrade than a firm operating in traditional manufacturing. A firm operating in a GVC with a market governance pattern is more likely to functionally upgrade than a firm in a hierarchical GVC.

The results support the argument of Humphrey and Schmitz (2000) that a hierarchical or quasi-hierarchical GVC makes it difficult to progress to the design and marketing functions of the chain. In terms of inter-sectoral upgrading, the estimation results identify three statistically significant variables with the highest average effect: R&D laboratory, R&D investment and region. The results suggest that firms located in Mexico City are more likely to achieve functional upgrading and/or inter-sectoral upgrading, respectively, vis-à-vis unsuccessful applicants located in the north. However, if firms are located in other parts of the country, there seems to be no significant effect on the likelihood of firms to achieve these types of upgrading.

With respect to recipients and the second control group (non-applicants), the second estimation reports six statistically significant explanatory variables affecting functional upgrading: governance pattern in GVCs –with the highest average effect – followed by ownership, R&D laboratory, region, sector and external economies of clustering. The effect of region (i.e., recipients located in Mexico City vis-à-vis the north) increases when considering combined effects (interactive terms 1 and 2) with having an R&D department or with the presence of external economies of clustering. With respect to the estimation of inter-sectoral upgrading including recipients and control group 2 (non-applicants), six variables were found to be statistically significant: business age, R&D employment, R&D department, structure, exporter and external economies of clustering.

In general, the average effect of R&D laboratories is one of the highest factors in achieving functional upgrading. This effect increases when combined with the effect of region. This supports the argument of Rush, Bessant, Hobday, Hanrahan, and Medeiros (2014) that technological capabilities are key to adapting, improving and generating new technology endogenously. These capabilities increase innovation capacities and are essential to economic development. The accumulation of technological capacity is at least as important to economic development as capital

Table 4. Bi-probit model, with sample selection, explaining the factors correlated to the propensity to achieve functional upgrading (FU) or inter-sectoral upgrading (ISU) considering interaction effects.

	Recipients versus control group 1								Recipients versus control group 2							
	Structural equation		Selection equation		Structural equation		Selection equation		Structural equation		Selection equation		Structural equation		Selection equation	
	Dependent variable: Functional upgrading		Dependent variable: Government support		Dependent variable: Inter-sectoral upgrading		Dependent variable: Government support		Dependent variable: Functional upgrading		Dependent variable: Government support		Dependent variable: Inter-sectoral upgrading		Dependent variable: Government support	
	Coefficient	*t*-value	Coefficient	*t*-value	Coefficient	*t*-value	Coefficient	*t*-value	Coefficient	*t*-value	Coefficient	*t*-value	Coefficient	*t*-value	Coefficient	*t*-value
Ownership	0.128	0.382	0.577*	0.318	0.233	0.425	0.507*	0.427	0.465*	1.251	0.423*	0.812	0.286	0.489	0.507*	0.427
R&D employment	0.327	0.257	0.511*	0.282	0.304	0.492	0.491*	0.341	0.267	0.342	0.498*	0.621	0.293*	0.593	0.491*	0.341
R&D laboratory	1.721**	0.702	0.588**	0.201	1.651*	0.692	0.429**	0.345	1.928***	0.882	0.326**	0.352	0.307	0.378	0.429**	0.345
R&D department													0.753*	0.657	0.389	0.492
Size (number of employees in 2009 in logs)	0.322	0.472	0.127*	0.075	0.632	0.782	0.271*	0.111	0.283	0.387	0.301*	0.132	0.283	0.423	0.271*	0.111
Structure (1: subsidiary of other firm; 0: independent firm)													–0.412**	–0.329	0.392	0.477
Structure (1: venture business; 0: independent firm)	–0.432*	–0.221	–0.256	–0.473												
Exporter (1 = yes; 0 = otherwise)	0.538	0.622	–0.278*	–0.226	0.432	0.558	–0.125*	–0.432	0.328	0.246	–0.012*	–0.361	0.542**	0.697	–0.125*	–0.432
Sector (1: complex products; 0: traditional manufacturing)									0.811*	0.634	0.288	0.467				
Sector (1: specialized suppliers; 0: traditional manufacturing)	–0.504**	–0.153	0.543	0.672												
Governance pattern in global value chain (1; market; 0: hierarchical)	1.473**	1.931	0.282	0.538					1.683**	1.305	0.891	0.598				
Clustering: specialized labour market availability									0.640**	0.782	0.934	0.926				
Clustering: local inputs available													0.612*	0.478	0.118	0.381
R&D linkages	0.215	0.367	0.411*	0.216	0.239	0.341	0.382*	0.314	0.312	0.485	0.527*	0.161	0.317	0.379	0.382*	0.314
R&D investment	0.189	0.378	0.423*	0.22	0.721**	0.693	0.399*	0.298	0.513	0.472	0.502*	0.353	0.529	0.412	0.399*	0.298
Government support for business innovation	0.345	0.984	–	–	0.276	1.237	–	–	0.654	1.112	–	–	0.979	1.362	–	–
Region (1: Centre except Mexico City, 0: North)	0.789	0.835	0.432	0.563	0.623	0.892	0.485	0.523	0.558	0.694	0.423	0.501	0.472	0.491	0.511	0.532
Region (1: Mexico City; 0: North)	0.722*	1.764	0.392	0.461	0.230*	0.584	0.384	0.481	0.932*	2.168	0.412	0.472	0.867	0.921	0.734	0.743
Region (1: South, 0: North)	0.429	0.877	0.418	0.486	0.374	0.683	0.398	0.538	0.419	0.534	0.398	0.533	0.369	0.721	0.402	0.512
Region (Mexico City) × R&D laboratory	0.589*	0.321	0.323	0.426	0.325	0.493	0.482	0.488	0.523*	2.034	0.425	0.455	0.406	0.422	0.357	0.428
Region (Mexico City) × Clustering (specialized labour market availability)	0.375	0.421	0.321	0.438	0.311	0.978	0.277	0.426	0.492*	1.365	0.298	0.435	0.348	0.783	0.395	0.497
Political affinity	–	–	0.103*	0.101	–	–	0.098*	0.198	–	–	0.103*	0.101	–	–	0.098*	0.198
Observations	321				321				320				320			
Censored observations	113				113				82				82			
Uncensored observations	208				208				238				238			
Wald test (*p*-values)	0.423				0.624				0.327				0.589			

Notes: ***Significant at 1%; **significant at 5%; *significant at 10%; standard errors are robust.
Blank fields denote variables that have been dropped when estimating models due to their non-significance in initial estimations.

Table 5. Average marginal effects of bi-probit models, with sample selection, explaining the factors correlated to the propensity to achieve functional upgrading and inter-sectoral upgrading.

	Recipients versus control group 1				Recipients versus control group 2			
	Dependent variable: Functional upgrading		Dependent variable: Inter-sectoral upgrading		Dependent variable: Functional upgrading		Dependent variable: Inter-sectoral upgrading	
	dy/dx	*t*-value	*dy/dx*	*t*-value	*dy/dx*	*t*-value	*dy/dx*	*t*-value
Business age							0.008**	0.895
Ownership					0.149*	1.251		
R&D employment							0.079*	0.593
R&D laboratory	0.126**	0.702	0.019*	0.692	0.117***	0.782		
R&D department							0.025*	0.657
Size (number of employees in 2009 in logs)								
Structure (1: subsidiary of other firm; 0: independent firm)							–0.016**	–0.329
Structure (1: venture business; 0: independent firm)	–0.042*	–0.221						
Exporter (1 = yes; 0 = otherwise)							0.115*	0.697
Sector (1: complex products; 0: traditional manufacturing)	0.024	0.732	0.021	0.783	0.020*	0.634	0.021	0.732
Sector (1: specialized suppliers; 0: traditional manufacturing)	–0.084**	–0.153	–0.044	–0.423	–0.046	–0.367	–0.039	–0.389
Governance pattern in global value chain (1; market; 0: hierarchical)	0.131**	1.931	0.183	2.532	0.207**	1.305	0.118	2.102
Clustering: specialized labour market availability	0.011	0.827	0.009	0.731	0.011**	0.782	0.011	0.673
Clustering: local inputs available	0.002	0.524	0.005	0.473	0.003	0.589	0.004*	0.478
R&D investment (1 = yes; 0 = otherwise)			0.021**	0.693				
Government support for business innovation (1 = yes; 0 = otherwise)	0.013	0.984	0.017	1.237	0.025	1.112	0.018	1.362
Region (1: Centre except Mexico City, 0: North)	0.012	0.835	0.006	0.892	0.008	0.694	0.004	0.491
Region (1: Mexico City; 0: North)	0.179*	1.764	0.043*	0.584	0.024*	2.168	0.017	0.921
Region (1: South, 0: North)	0.032	0.877	0.027	0.683	0.026	0.534	0.021	0.721
Region (Mexico City) × R&D laboratory	0.015*	0.321	0.014	0.493	0.034*	2.034	0.015	0.422
Region (Mexico City) × Clustering (specialized labour market availability)	0.001	0.421	0.002	0.978	0.012*	1.365	0.011	0.783

Notes: ***Significant at 1%; **significant at 5%; *significant at 10%; standard errors are robust.
Blank fields denote variables that have been dropped when estimating models due to their non-significance in initial estimations.

accumulation. Another noteworthy result is that governance pattern in GVCs, clustering (external economies) and sector affect the likelihood of firms functionally upgrading in GVCs. These results suggest that hypotheses 1a–c cannot be rejected. This is linked with hypothesis 1d: regions are heterogeneous when achieving functional and/or inter-sectoral upgrading in GVCs.

DISCUSSION

Following prevailing 'best' practice in innovation policy evaluation techniques, the use of a bi-probit Heckman model as applied in this paper is an appropriate, systematic and rigorous method of estimating the impact of government support for business innovation on the likelihood of firms upgrading in GVCs in the case of a developing country such as Mexico. The use of two control groups to analyse the impact of such support in Mexico is an innovative feature of this paper.

Studies by Giuliani, Pietrobelli, and Rabellotti (2005) and Pietrobelli and Rabellotti (2006) relied on Likert scales when undertaking quantitative analysis with respect to 40 original case studies in Latin America; this was identified by the researchers themselves as a limitation of their own work. Responding to these studies, the testing of hypotheses 1a–c is the first attempt to identify directly causal relationships with respect to the likelihood of functional and/or inter-sectoral upgrading in GVCs. To extend the approach of these researchers, the two-step Heckman model with bi-probit regression analysis was used to identify the factors that affect the likelihood of firms upgrading functionally and/or inter-sectorally. The results corroborate the suggestion of Pietrobelli and Rabellotti (2006) that the likelihood of firms functionally upgrading is simultaneously affected by the governance pattern in value chains and the collective efficiency of clusters. In addition, it is shown that inter-sectoral upgrading is more difficult to achieve than functional upgrading. The implication is that different types of upgrading probability should be prioritized when designing policy programmes and interventions. In line with the prevailing literature on business innovation in developing countries, this paper finds that technological capabilities – measured by having an R&D laboratory – are key drivers in terms of achieving enduring and solid competitiveness in developing countries.

By testing the effect of region, the results further corroborate the findings of Chávez and Fonseca (2012), who claim that Mexico has strong inter-regional disparities in income and productivity. Moreover, the results of this model suggest that the effect of some variables (i.e., R&D laboratory and external economies of clustering) have more or less influence in different regions. This can be explained by the differences in regional development pathways and territorial embeddedness (Fold, 2014) between these Mexican regions. This study provides evidence by adding another inter-regional disparity: the likelihood of firms to achieve functional upgrading in GVCs.

However, even when controlling for selection bias, no evidence was found to support hypothesis 2: that government support for business innovation affects the likelihood of firms achieving functional and/or inter-sectoral upgrading. In this particular context (Mexico) and period (2006–09), the results suggest that government support did not make any difference in terms of influencing firms to achieve the type of upgrading required by developing countries; this is at odds with the expectations from studies by Pietrobelli and Rabellotti (2006). Given Mexico's stage of economic development, this paper's findings are surprising; further exploration of these issues in the context of Mexico and other developing countries could prove to be insightful. Possible reasons for this result may include institutional factors such as lack of a specific policy objective to support firms upgrading in GVCs or poor policy implementation. For instance, during this research, no specific policy instrument was found to be directly concerned with either functional or inter-sectoral upgrading in GVCs; therefore, although there are different instruments, they did not target the characteristics of these types of innovations. In terms of poor policy implementation, evidence is provided by ITAM (2008) who evaluated the administration of two policy instruments (i.e., R&D subsidies, R&D tax breaks) in Mexico over a period of two years. The main findings of the ITAM study referred to a lack of financial control in the disbursement of support, coupled with a long time lag between the allocation of grants and disbursement (on average taking more than 15 months). This created delays to recipient firms in starting their innovation projects. In 30% of the cases analysed, recipients just dropped out of the programme and the innovation projects never took place. Although this is only a small sample of all the instruments of government support for business innovation in Mexico, their results suggest the existence of some government failure (Haapanen, Lenihan, & Mariani, 2014).

CONCLUSIONS AND POLICY IMPLICATIONS

This paper contributes to the theories of the impact of innovation policies in developing countries and GVCs and provides new evidence. An adequate and appropriate evaluation framework was developed that allowed the testing of the impact of region and government support for business innovation on the likelihood of firms' upgrading in GVCs in Mexico. This framework makes the measurement of the likelihood of firms upgrading in GVCs possible. Moreover, this study constructed a unique dataset and employed econometric analysis to test the effectiveness of business innovation policies, and stylized facts available in previous qualitative empirical analyses. The paper highlights and models key factors of particular relevance in evaluating support for business innovation in developing countries with particular reference to Mexico. Such factors include technological capabilities and absorptive capacities in the form of R&D laboratories and formal R&D departments.

The construction of the database used in this study represents an original contribution to knowledge given the nature of the firm-level data obtained. Methodologically, this paper makes a novel contribution to the innovation policy evaluation literature by using a dual-control-group analysis to gain a precise picture of the extent of the impact of government support for business innovation.

From a policy perspective, the results suggest that government support for business innovation in this particular context (Mexico) and period (2006–09) did not affect the likelihood of firms upgrading in GVCs. The variables identified as affecting functional and/or inter-sectoral upgrading can, however, serve as a guide to policy-makers as they design future innovation policy interventions and instruments in the context of developing countries. The results also suggest that some variables have different effects in different regions. This indicates regional heterogeneity which should be borne in mind when designing a policy intervention, as proposed by Fritsch and Storey (2014).

Additional and currently unexplored questions arise from the findings of the paper and merit future investigation. For example, how do the effects of government support for business innovation evolve over time? What is the effect of government support for business innovation on other issues, such as behavioural additionalities? How might functional and inter-sectoral upgrading affect the performance of firms? What are the effects of product and process upgrading on the performance of firms? How do different government innovation policy instruments specifically affect the promotion of business innovation in developing countries such as Mexico? Related to this issue, are some instruments more 'optimal' than others, and in what contexts? In line with the work of Dolan and Humphrey (2004), it would be interesting to investigate the restructuring of GVCs between Mexico and its trade partners as a consequence of the global economic crisis, and the effects of changes in governance patterns on the likelihood of firms to upgrade. The ideas presented in this paper are merely the first step in this type of analysis. However, in spite of the nuances highlighted throughout this paper, there is no denying that the non-significance of public policy intervention for business innovation is a very important result of the current research. It points towards a Mexico-specific context that justifies more investigation with deeper analysis and is certainly a field ripe for future research.

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NOTES

1. Government support for business innovation is defined in this paper as any type of policy instrument used by policy-makers to increase business innovation activity in Mexico during 2006–09. During the period under investigation (i.e., 2006–09), the Mexican government granted support for innovation to firms using a variety of instruments. R&D tax breaks and subsidies were the main instruments, while other instruments included strategic alliances, innovation networks for competitiveness, the operation of technology-transfer offices as well as acquisition of intellectual property rights (CONACYT, 2011).
2. Defined as factories or assembly plants operated and usually located in the north of Mexico under preferential tariff programmes.
3. North region comprises the states of Baja California Norte, Baja California Sur, Sonora, Chihuahua, Sinaloa, Durango, Coahuila, Nuevo Leon, Zacatecas, San Luis Potosi, Tamaulipas and Nayarit. Centre region (except Mexico City) comprises of Aguascalientes, Jalisco, Guanajuato, Queretaro, Hidalgo, Colima, Michoacán, Morelos, Tlaxcala, Puebla and Veracruz. Mexico City region comprises Distrito Federal and Estado de Mexico. South region: Guerrero, Oaxaca, Chiapas, Tabasco, Campeche, Yucatan and Quintana Roo.
4. There is a potential problem in the estimation of the timing of innovation output vis-à-vis the timing of business innovation policy implementation. Firms were asked if they received government support for business innovation during 2006–09, without specifying precisely when they received it; then they were asked if they achieved upgrading in GVC during the period. This analysis was taken within the constraints of an evaluation using cross-sectional survey data; a number of specific issues arose. First, the nature of government support for business innovation allows firms to draw down the monies offered over a three-year period, which means that a business receiving an offer at the end of 2009 will perhaps not have fully realized the benefits of assistance; therefore, the model may underestimate the effects of assistance. Second, assistance received at the start of the period (i.e., 2006) may already have had its effect on the firm or plant; to model firm performance in a period far removed from the point of assistance may be problematic and lead to an overestimate of the effects of assistance. Third, there is an assumption that the actual realization of the effects of government support received by firms in 2006–09 will be fully captured by the model. This may not be the case and again may underestimate the effects of government support for business innovation.

However, whilst bearing in mind these limitations and caveats, it is important to highlight the indicative nature of the results and findings which yield insights from an academic and policy-making perspective.

5. A relatively large sample is used and a bespoke survey designed, which provides a rich and distinct variable set for both the selection and upgrading (performance) models.

6. The authors are grateful for two anonymous reviewers' comments which allowed them to improve the model with a more concise specification by means of identifying relevant variables and using a more appropriate functional form of the model, that is, a bi-probit. This resulted in a more robust estimation.

7. Whether or not the firm is located in a cluster with an available specialized labour market, available local inputs and/or ease of access to information and markets.

8. Formal linkages made by the firm in order to collaborate with partners (e.g., universities) in R&D activities. Although Nadvi (1999) identified three different types of joint action (vertical, bilateral horizontal and multilateral horizontal), respondents to the survey were unable to recognize the type of joint action. Therefore, this study measures this variable by whether or not the firm has formal collaboration through R&D linkages.

9. This is a relative measure in terms of total turnover in 2009 in order to construct it as a continuous variable. Originally, this measure was binary taking the value 1 if more than MXN$1 million annually, 0 if less. MXN$ = Mexican pesos (cut-offs were adopted from the Ibero-American Network for Science and Technology Indicators – RICYT, 1999).

10. Until 2009, RENIECYT comprised 3827 firms. According to SIICYT (2011), this database is representative in terms of firm size, sector and location of a total population of approximately 4 million firms operating in Mexico.

11. Up until 2009, the Mexican government granted more than 2000 supports to innovation in the form of R&D subsidies, R&D tax breaks and R&D network alliances (CONACYT, 2011).

12. The sample comprises applicants for government support for business innovation during 2006–09 and represents 12.46% of the RENIECYT population.

13. Constructing the latter group had two aims: first, to compare the group of recipients with firms that decided to apply for government support for business innovation but were unsuccessful; and second, to reflect the wider business population operating in Mexico that had not applied for government support for business innovation.

14. Interaction effects regarding size were considered in the original models, and they turn out to be statistically non-significant. Therefore, these interaction effects are not included in the final models.

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