The effect over time of Related and Unrelated Variety on Types of Regional Innovation in Brazil

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Abstract

This paper investigates the impact of related and unrelated variety on innovations protected by utility model and patent in Brazil (). Additionally, we analyse the role of regional absorptive capacity in this relationship. We find that Brazilian regions benefit from both types of variety, but in different ways for each types of innovation. The positive effect of related variety on innovation protected by patent is shaped by levels of absorptive capacity. Such effects cannot be found for innovation protected by utility model. Besides, we finds that innovation protected by patent benefit more than utility from unrelated variety and this relation is not shaped of region's absorptive capacity.

Keywords: Geography and Innovation; Related and Unrelated Variety; Regional Productive Structure
CODES: O31; O18; R12

Introduction

The role of industry structures for economic development has been sorely discussed in the literature (Glaeser et al. 1992; Henderson 1997; Combes et al. 2009), and the role of knowledge spillovers has been a key issue. On the one hand, a group of authors argue that knowledge spillovers are more frequent among specialized industrial structures (Marshall-Arrow-Romer externalities). On the other hand, others claim that the diversified industrial structure, through recombination of knowledge across sectors, promotes knowledge spillovers and is conductive for innovation (Jacobs 1969).

Empirical evidence is far from conclusive because both evidences were found in the literature (Beaudry and Schiffauerova 2009; De Groot, Poot, and Smit 2009). Some studies highlight the benefits of diversity for innovation Audretsch and Feldman (1999) and Carlino et al. (2001) for American regions; Van Oort et al. (2002) for Netherlands regions; Co (2002), Fritsch and Slavtchev (2010) for German regions.Furthermore, specialized agglomeration can be harmful to innovation, since it can lead to lock-in, preventing the emergence and development in other essential areas to innovation (Feldman and Audretsch 1999; Carlino, Chatterjee, and Hunt 2001; Co 2002; Fritsch and Slavtchev 2010).

In contrast, other studies, such as Henderson (1999) to the United States; Van der Panne (2004) for the Netherlands; Cabrer-Borrás and Serrano (2007) for Spain; and Crescenzi et al (2012) for Chinese regions; emphasize the role of industrial specialization in the regions to foster innovation, because they found that the performance of innovative regions depends on the specialization of its scientific and technological base (Henderson 1997; Van Der Panne 2004; Cabrer-Borras and Serrano-Domingo 2007; Crescenzi, Rodríguez-Pose, and Storper 2012).

Joint evidence for both types of production structure have also been found by Paci and Usai (1999, 2000) and Greunz (2004) that point out that regional innovation is positively affected by both externalities, specialization and diversification. Thus, the best production structure industry that supports innovation can differ from one place to another (Paci and Usai 2000; Greunz 2004).

Altogether, empirical findings of the analysis of the effect of regional industry composition on innovation are inconclusive. This may be partly attributed to the diverse methodological approaches and levels of spatial and sectoral aggregations that have been applied. Another reason may be consider a distinction of sectoral structures into diversified or specialized as an oversimplification (Beaudry and Schiffauerova 2009).

Frenken et al. (2007) pointed to the oversimplification regard to the concept of Jacobs externalities. They stand out the need of a deep understand of diversification based on the degree of relatedness, namely, to split it into a related and an unrelated part. According to Frenken et al. (2007) different types of variety have to be distinguished, since it can have different effects on a region’s economic performance. The main argument is that the related variety in a region is favourable to the emergence of knowledge spillovers that generate innovations thus creating positive effects on regional growth. In contrast, a diversification of unrelated industries (unrelated variety) is less likely to promote such spillovers effects due to a larger technological and cognitive distance between actors in these industries (Frenken, Van Oort, and Verburg 2007).

The conceptualization of diversity, and the initial empirical evidence, gave enormous rise to further investigations. Several empirical studies were done, especially applying it to European countries (Boschma and Iammarino 2007; Nooteboom 1999; Krafft, Quatraro, and Saviotti 2014; Frenken, Van Oort, and Verburg 2007; Kublina 2015; Fritsch and Kublina 2018).

However, the use of variety concept to emerging economies is rare. This paper provide new empirical evidence in this respect explore the effect of related and unrelated varieties on different types of regional innovation in Brazil (inventions protected by patent or utility model). Besides, we analyse the role of region's absorptive capacity on this relationship.

We find that Brazilian regions benefit from both types of variety, but in different ways for each types of innovation. The positive effect of related variety on innovation protected by patent is shaped by levels of absorptive capacity. Such effects cannot be found for innovation protected by utility model. Besides, we finds that innovation protected by patent benefit more than utility from unrelated variety and this relation is not shaped of regional absorptive capacity.

Database

In this section, we provide brief details of the datasets used, followed by a discussion of the dependent variable, the variables of interest and controls. For this research, we constructed database from three sources. The first source is the Brazilian Patents Office (*INPI - National Institute of Industrial Property*), which contains information about inventions protected by utility model and patent. The second source is the Annual Report on Social Information (RAIS) of the Ministry of Labour that covers the register of formal employment, which allows us to analyse regional industrial structures and regional absorptive capacity. The third source is the Brazilian Institute of Geography and Statistics (IBGE) that contains others information as GDP and population.

The analysis covers 558 Brazilian micro regions, which corresponds to the to the EU NUTS-3[1], and the period of analysis is 2002-2017

Empirical Model

The basic structure of the empirical models for analysing the relationship between related and unrelated variety and regional innovation performance is:

$$INNOV_{r,T+3} = \beta_1 RV_{r,t} + \beta_2 UR_{r,t} + \beta_3 Interation_{r,t} + \beta' X_{r,t} + \lambda_i + \nu_{it}$$

$INNO_{r,T+3}$ denotes the number of the innovations protected by utility model or patent over three-year period (*T+3*) granted by the Brazilian Patent Office divide by population in micro-region *r*. $RV_{r,t}$ and $UV_{r,t}$ are the measure of the related and unrelated variety in region *r* in time *t* one year previous *T+3*. $Interaction_{r,t}$ represent the variables that are supposed to capture the moderating effect of absorptive capacity on the relationship two types of variety and regional innovation. $X'_{i,t}$ is a vector of further variables, λi are the unobservable effects specific to each region and ν_{it} are the remaining unobservable effects that vary both for regions and over time.

Our data allows us to construct a balanced panel with 4 time period, since we have four observations for each micro-region relating to over three-year period 2003-2005, 2007-2009, 2011-2013 and 2015-2017. We attempt to mitigate the potential endogeneity and simultaneity problems could emerge measuring all exploratory variables at the time *t* (2002, 2006, 2010 and 2014) that is not included in three-year period of dependent variable. Due the dependent variable characteristics we applied random-effects *tobit* model for panel data.

Regional Innovation in Brazil

In Brazil, as in a number of countries, the inventions can be protectable through two form of registration: utility model and patent. The invention standard protected by utility model is lowered compared invention protected by patent. For example, an

[1] Micro-regions are defined as a cluster of cities created for statistical purposes. It can be associated with the EU-NUTS3.

innovation or a utility model can use products or inventions that have already been invented in a new and innovative way to solve a particular problem. In general, offers protection time lower than patent. Because this, utility model may also be called 'short-term patent' or 'petty patent'or 'incremental innovation.

Therefore, we differentiate innovations protected by utility model and patent, considering that the novelty of a utility model is an innovation that has a lower degree of novelty than a patent. In this way, we analyse how the relationship of these two innovations and the types of variety is.

The dependent variable is defined from types of regional innovation measured as the number of utility model over a three-year period per capita and the number of patent over a three-year period per capita. In table 1, we show the number of utility model and patent in periods of analysis

Table 1: The number of utility model and patent

	Utility Model	Patent	Total
2003-2005	10.311	11.949	22.260
2007-2009	9.666	12.723	22.389
2011-2013	8.795	14.458	23.253
2015-2017	8.265	15.319	23.584

The number of utility models decreased in the periods of analysis while the number of patents increased. And the total also increased in these periods of analysis in Brazil.

Figure 1 shows the distribution of innovation across the Brazilian micro-regions final period of our analysis (2015-2017). As in other developed and developing countries, the regional distribution of innovation in Brazil shows a strong tendency towards an unequal concentration in a few some regions (Gonçalves and Almeida 2009; Garcia, Araujo, and Mascarini 2013). This concentration is in South, Southwest and Midwest of Brazil. The most important micro-region regarding innovation is São Paulo that presents 16,4% and 14,7% of utility model and patent, respectively. Followed by micro-regions where are the capital of federative units, as Rio de Janeiro, Belo Horizonte, Curitiba and Porto Alegre.

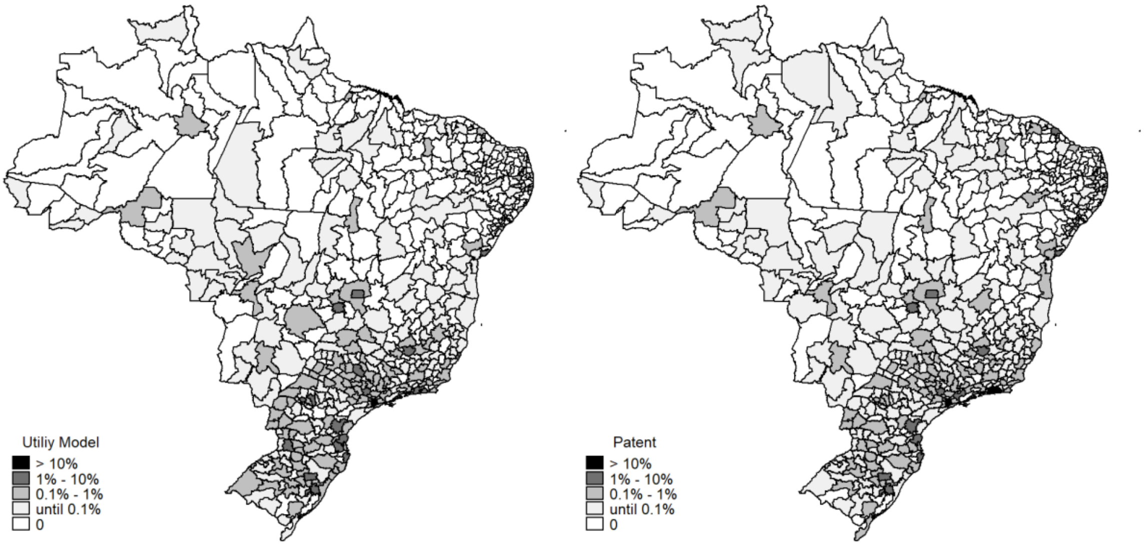

Figure 1: Innovation Distribution between Brazilian Micro Regions (2015-2017)

Related and Unrelated Variety

Following Frenken et al. (2007), we used of the entropy measure to indicate both types of variety (related and unrelated) at different levels of sectoral aggregation. We used the number of employees in manufacturing industries in the Brazilian micro-regions at the 5-digit SIC industries. The related and unrelated variety are calculated as follows:

$$UV_r = \sum_{c=1}^{C} P_c \log_2 \left({}^{1}/_{P_c} \right) \qquad with \;\; P_c = \frac{p_i}{\sum_c p_i}$$

$$RV_r = \sum_{c=1}^{C} P_c H_c \quad with \;\; H_c = \sum_{d \in S_c} {}^{P_d}/_{P_c} \log_2 \left({}^{P_c}/_{P_d} \right)$$

The unrelated variety measures the average degree of variety of the sectors (2-digit SIC industries). The value of unrelated variety can vary from 0 (all employment is concentrated in only one sector) up to 4.57 (all sectors employ an equal number of employees)[2]. The related variety measures the average degree of variety of employment in subsectors (5-digit SIC industries) belonging to the same sectors. The value of the related variety range from 0 (employment in each sector is concentrated in only one of its subsector) to 3.52[3]. In this way, the lower is the value of the (un)related variety index, the less evenly is employment spread across the sectors/subsectors indicating a

[2] Since our empirical analysis is based on 29 sectors (two digit industries - G) and maximum limit for unrelated variety is log2(G).
[3] Since our empirical analysis is based on 310 subsectors (five digit industries - D) within 29 sectors (two digit industries - G) the maximum limit for related variety is log2(D)-log2(G).

lower share of (un)related industries in a region (Boschma and Iammarino 2007; Nooteboom 1999; Krafft, Quatraro, and Saviotti 2014; Frenken, Van Oort, and Verburg 2007).

The table 2 shows the averages of unrelated and related variety in Brazilian micro-regions in years of analysis.

Table 2: Averages of unrelated and related variety in Brazilian Micro-regions

	2002	***2006***	***2010***	***2014***
UV	2.24	2.30	2.35	2.43
RV	1.11	1.15	1.17	1.21

Taking into account the theoretical upper bound of unrelated variety measure is 4.57 and related variety is 3.52. Even though the variety indexes have increase in the years analysed, the averages of variety indexes indicate that the employment is distributed rather unequal across both related and unrelated industries in Brazil micro-regions. Such low indicators might be explained by difficulties to attract or diversify industrial composition into any level as in many peripheral countries

Figure 2 shows the distribution of related and unrelated variety across Brazilian micro-regions in 2014 which is the outset of the final period of our analysis.

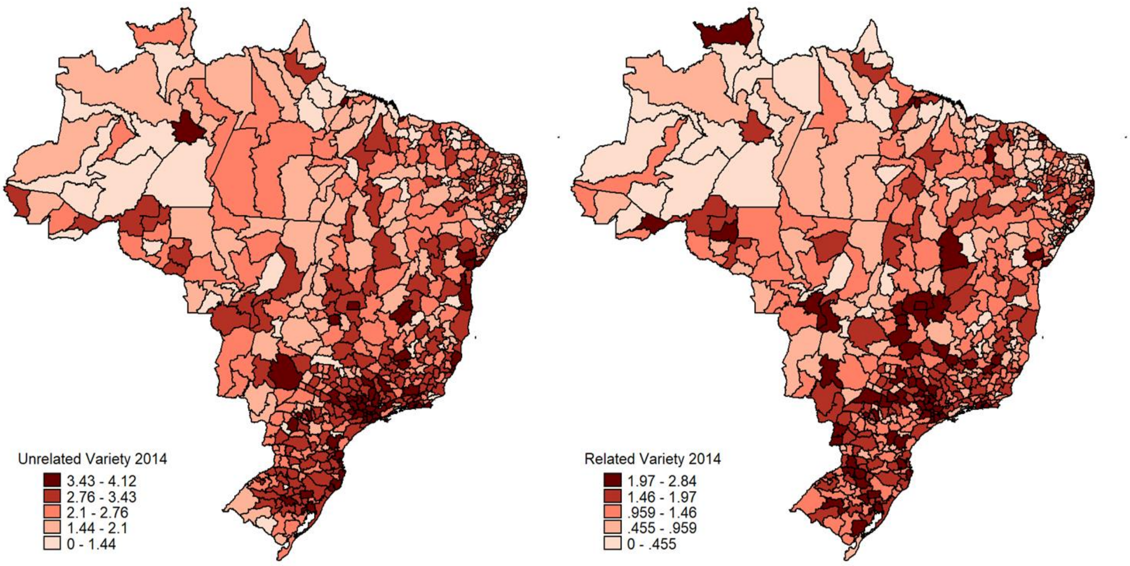

Figure 2: Distribution of related and unrelated variety in Brazilian micro-regions, 2014

Most micro-regions with high level of related and unrelated variety are located in the south, southwest and middle of the Brazil. In the north and northeast the micro-regions with high level of related and unrelated variety are also micro-regions high density population or where located the capital of federative unit.

<u>Other Exploratory Variables</u>

In addition to the main variables of interest we consider the controls. The first control is the region's absorptive capacity or R&D intensity measured as the natural logarithm of the average wage of higher education employees in S&T. This control represents an important input of innovation. Absorptive Capacity improves region's capacity to generate new knowledge and can give them the ability to internalize knowledge from other sources. In this way, the interaction of regional variety indexes and R&D test whether different levels of absorptive capacity have a moderating effect on the relationship between variety and innovation. A significantly positive sign of the variable would indicate stronger effect of variety for regions with higher levels of absorptive capacity.

The second control is relative wealth proxy by the natural logarithm of gross domestic product (GPD) per capita that reflects a regional's overall level of development. The third is a dummy for south, southeast and middle. Finally, we control initial number of utility model or patent. The main goal of incorporating this variable is to control the different initial patterns of technological capability in the region, which may also reflect differences in the region's propensity for innovative capability. The table 3 summarizes the definitions of the variables used.

Table 3: Definition of variables

Variable		***Definition***
Types of Regional Innovation	***UMperc***	# inventions protected by **Utility Model** over the respective three-year period per capita
	PAperc	# inventions protected by **Patent** over the respective three-year period per capita
Unrelated Variety	***UV***	Entropy across sectors
Related Variety	***RV***	Weighted sum of entropy at the subsectors of the industry classification within each sectors
Interaction	***lnRDUV***	Interaction between Absorptive Capacity and **UV**
	lnRDRV	Interaction between Absorptive Capacity * **RV**
Absorptive Capacity	***lnRD***	Average wage of higher education employment in S&T.
Relative wealth	***lnGDPper***	Gross domestic product divide population
Dummy	***D_SCO***	Dummy for south, southeast and middle
Initial Innovation	***L1PAper***	Initial # inventions protected by **Utility Model** over the respective three-year period per capita
	L1UMper	Initial # inventions protected by **Patent** over the respective three-year period per capita

Results

In order to explore the relation between the related and unrelated varieties and types of regional innovation in Brazil we apply the dynamic *tobit* model for panel data. We estimate three different models to analyse the effects of related and unrelated on two types of regional innovation (Table 4). The model I is base model, the models II and III test whether different levels of absorptive capacity have a moderating effect on the relationship between types of variety and innovation. We do not include both interactions of our indicator for regional absorptive capacity (R&D intensity) with the variety indexes to one model due to the pronounced multicollinearity that is obviously due to R&D intensity being included three times.

Table 4: Results from Estimated Models for regional innovation.

VARIABLES	*UMperc*			*PAperc*		
	Model I	*Model II*	*Model III*	*Model I*	*Model II*	*Model III*
RV	0.109***	0.197***	0.111***	0.112***	-0.00373	0.105***
	(0.0185)	(0.0667)	(0.0187)	(0.0222)	(0.0633)	(0.0207)
UV	0.0496***	0.0523***	0.102**	0.0970***	0.0886***	0.117**
	(0.0146)	(0.0147)	(0.0448)	(0.0174)	(0.0162)	(0.0460)
IntRDRV		-0.0113			0.0140*	
		(0.00813)			(0.00780)	
IntRDUV			-0.00673			-0.00330
			(0.00544)			(0.00562)
lnRD	0.0116***	0.0224**	0.0252**	0.0117***	0.00120	0.0199*
	(0.00397)	(0.00892)	(0.0118)	(0.00441)	(0.00779)	(0.0121)
lnGDPperc	0.115***	0.117***	0.117***	0.158***	0.146***	0.149***
	(0.0158)	(0.0158)	(0.0159)	(0.0186)	(0.0177)	(0.0178)
D_SCO	0.154***	0.152***	0.152***	0.0833***	0.0797***	0.0747***
	(0.0215)	(0.0215)	(0.0215)	(0.0252)	(0.0234)	(0.0234)
L1PAper				0.804***	0.837***	0.846***
				(0.0328)	(0.0255)	(0.0255)
L1UMper	0.731***	0.733***	0.732***			
	(0.0218)	(0.0219)	(0.0219)			
Constant	-0.806***	-0.900***	-0.916***	-0.965***	-0.831***	-0.986***
	(0.0455)	(0.0836)	(0.102)	(0.0542)	(0.0734)	(0.103)
Observations	1,674	1,674	1,674	1,674	1,674	1,674
Number of id	558	558	558	558	558	558
chi2	2522	2502	2506	2277	2907	2871

In general, the results of the models reveal significant and positive impacts for both industry varieties on types of regional innovation. In models I in table 4, we find a significant and positive impact of related and unrelated variety on both types regional innovation - utility model (*UMperc*) and patent (*PAperc*). However, whether we compared magnitude this impact the results indicate that the effect of related variety tends to be more pronounced than effect of unrelated variety on utility model.

Additionally, the benefit from both types of variety, related and unrelated, is similar on patent. The other words, the diversification of related variety in a micro-region creates higher positive effects than unrelated variety on utility model. In contrast, the diversification of both varieties in micro-region creates similar positive effects on patents. This result is in line the literature suggesting that incremental innovations benefit most from the related industrial composition whereas unrelated industrial composition must be extremely important for radical innovations. In this way, important differences may exist between the types of innovations that are induced by spillovers from related and unrelated industries (Castaldi, Frenken, and Los 2015; Boschma and Capone 2015)

Adding interactions in model I show no statistically significant effect on utility model (***Models II and III, UMperc***), indicating that there is no different effect the both types of variety for regions with higher levels of absorptive capacity.

For patent, the interaction of R&D intensity (absorptive capacity) with related variety is positive and significant, suggesting that the effect on patent of knowledge spillovers among related industries rises with the level of region's absorptive capacity.

In contrast, interaction of R&D intensity with unrelated variety is not significant, indicating that there is no different effect of variety for regions with higher levels of absorptive capacity. In this way, higher levels of regional absorptive capacity can facilitate the spillovers among related fields of knowledge, but are not important for spillovers between unrelated fields. In the other words, the moderating effect the absorptive capacity only is present on relationship between patent and related variety

Preliminary Conclusion

This paper sought to put more light on the relationship between the type of variety and the types of regional innovation in Brazil. Brazil, as a many peripheral countries, presents structural differences in its innovation system and a higher concentration of low level innovations. Using related and unrelated variety concept, this paper tries to understand how regional industrial sectors implies in more or less innovations of each novelty degree (incremental - utility model or radical - patent).

Our empirical analyses showed that micro-regions in Brazil benefit from both types of variety, related and unrelated, but there are some differences between inventions protected by patent and utility model.

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