



## THE MOBILITY OF SKILLED WORKERS AND INNOVATION IN BRAZIL

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**Abstract:** The analysis of locational factors is the key to understand the localization of innovation. The mobility of skilled workers is one of these factors. The mobility of workers is important for innovation activities because the knowledge is embodied in people. The aim of this article is to evaluate if the mobility of skilled workers can influence the regional innovation in Brazil. The mobility was analyzed with micro-data of formal workers between the micro-regions of Brazil on the years of 2003 to 2008. The indicators of mobility were created for total workers, workers with higher education and workers in technical and scientific occupations in selected economics activities. The knowledge production function framework at the regional level was used. The empirical approach shows that the inflows and outflows of workers are beneficial for innovation. The circulation of skilled workers is an important element in the analyses of regional innovation.

**Keywords:** Innovation, Skilled workers, Mobility and Knowledge flows.

**Codes JEL:** D62, O15, O31

**ABEIN Area:** 4.2 Economias Regionais e Urbanas



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### Introduction:

There is a growing literature that investigates the extent to which the presence of qualified workers in a region can lead to greater possibilities for knowledge exchange among different agents. In this context, the analysis of the characteristics and implications of mobility of workers for regions is a relevant question. The mobility of workers is one of the mechanisms that increase the intensity and concentration of knowledge flows, as well as being a key element to explain the geographical concentrations of innovative activities (Breschi & Lissoni 2009; Gagliardi 2015; Lenzi 2013). It can enrich the local knowledge base. Knowledge is embedded in people, in their tacit knowledge and in their abilities to decode codified knowledge (Fratesi 2014; Breschi & Lenzi 2010; Lenzi 2013).

Along these lines, authors have been studying the role of knowledge and skilled workers and their mobility patterns as a vehicle for the diffusion of knowledge (Fratesi 2014). The idea is that knowledge flow and its geographical distribution tends to develop according to the trajectories of individuals that produce and possess knowledge. The mobility itself may not have a positive effect over the regions, especially when the workers mobility does not involve qualified and complex knowledge (Breschi & Lenzi 2010; Lenzi 2013).

In this perspective, the aim of this research is to evaluate if the mobility of skilled workers can influence the results of innovation. The benefits generated by skilled workers' mobility in a region can positively influence the innovative results of geographically nearby companies.

This work contributes by presenting empirical evidence on the role of skilled workers' mobility as an important source of knowledge flows. There is a lack of evidence about this theme (Lissoni 2018; Maré et al. 2014; Gagliardi 2015; Crescenzi & Gagliardi 2015). Moreover, such analyses are still scarce for developing countries with continental dimensions. In Brazil, the analysis of the mobility of skilled workers is based on the evaluation of the determinants of mobility, admitting that skilled workers can be instruments of knowledge diffusion (Mendes et al. 2012; 2017; Taveira et al. 2014). Thus, there is no evidence of the effect of skilled workers' mobility on innovation.

The empirical strategy is based on the knowledge production function that estimates innovation measures as a function of regional factors (Griliches 1979; Jaffe 1989). Innovation is the dependent variable - measured by the average of patents per capita in 2009-2011. Mobility of skilled workers is one of the independent variables and it is the regressor of interest. The measure of mobility of workers used data from the Brazilian Ministry of Labor, which covers all formal labor market in specified year.

Three measures of mobility were constructed: mobility of the total workers (TO), mobility of workers with higher education (HE) and mobility of workers in technical and scientific occupations (TS) in selected economic activities. The last two



(HE and TS) were considered mobility of skilled workers. Additionally, it was analyzed the mobility of workers that occurred between micro-regions that are classified in the same metropolitan area by IBGE (intra-metropolitan areas). The results pointed to a positive relationship between innovation and circulation of skilled workers in Brazil.

This paper is organized as follows. The next section presents the main conceptual background regarding mobility of skilled workers and its influence in knowledge flow and innovation. Section 3 provides a description of the main variables of the model: the measure of innovation and the measure of workers' mobility. The fourth section presents the empirical model and other variables used in the empirical strategy. The next section presents the results and the discussion. Finally, the last section offers some concluding remarks.

### **Main conceptual remarks:**

The skilled workers' mobility is a growing area of study in literature that relates geography and innovation. The mobility of workers is important for fostering the innovation because the knowledge is embedded in people and the movement of these people in the space can be considered a crucial mechanism of knowledge diffusion between firms and regions (Boschma et al. 2014; Gagliardi 2015).

The knowledge flows tend to follow and develop according to trajectories of mobility from individuals that have and produce knowledge. The tacit and idiosyncratic attributes of knowledge, that are relevant to the innovation activities, are transferable and the diffusion is related with the presence of social and professional contacts. Although the social relations are developed and stabilized at the local level, the social relations can create networks. These relational networks are important for persistence of the contacts with different agents even after that agents move for different geographical areas. It is possible to assert that geography matters, since previous location of the workers allows generation of social relations and therefore, shapes and directs the geographic distribution of knowledge flows (Breschi & Lenzi 2010).

However, it is important to point that mobility itself may not have effects on the knowledge flows, especially if the mobility does not involve workers with qualified and complex knowledge. Knowledge that is not qualified may not be absorbed by the agents located geographically near (Breschi & Lenzi 2010; Breschi & Lissoni 2009). The effect of mobility depends on the types of abilities that are exchanged amongst different agents (Boschma & Iammarino 2009). For example, the firm will have a better performance if the new employer brings an ability that is related with the ability that already exists in the portfolio of the firm. Furthermore, this new ability may only be accessed by the firm if it has absorptive capacity to understand and integrate this new ability in its activities (Boschma et al. 2014).

In this perspective many articles present the relation amongst the knowledge flow and the regional level (Boschma et al. 2014). There are studies about the importance of workers mobility in the convergence of regions, other studies investigate the role of social capital for the firms when workers move to different firms and studies



about the importance of mobility of stars scientists (Fratesi & Percoco 2014; Angeli et al. 2014; Lenzi 2013).

Regarding innovation and mobility of qualified workers a few articles have been identifying a positive relation amongst the presence of migrants and innovation level. The migration of skilled workers may increase competitiveness and growth of the regions, which may create long term benefits (Maré et al. 2014). In this line, there is a number of mechanisms that explain the influence of migration on innovation: migrants change the workforce composition, they have different types of knowledge that is not available in the population non-migrant, they increase the knowledge diversity through the local interaction, they have embodied knowledge and have access to people and networks in different places in the world. The interactions that contribute for these effects are diversified, such as the face to face contacts, the formal networks and the informal relations that occur in the clusters (Maré et al. 2014). If the interactions are not confined in the firm, the regional workforce composition influences the innovations activities of others firms (in special, for small and medium firms). Gagliardi (2015) asserts that skilled workers migration is one of the mechanisms of knowledge flows. The benefits of influx of skilled workers may be two: direct effect and indirect effect. The direct effect is associated with formal labor market; the indirect effect is related with the possibilities of existence of externalities, derived from accumulation of human capital in specifics spatial contexts. The positive impact of mobility occurs when the firm has an interaction with the external environment. That is, when the firm uses external information source.

In this line, Crescenzi and Gagliardi (2015) point out that literature about the impact of mobility in innovation isn't fully exploited. However, the literature has convergence in three points: the relation amongst mobility and innovation is heterogeneous and it depends on the characteristics migrant's individual, the receptor firms and the local labor market; the contract is only one aspect of knowledge spillovers in the local level; and the impact of influx of qualified workers is affected by the way in which firms and others economics agents search yours knowledge source, building or not connections with the local.

Furthermore, another concept used in the analysis of mobility of workers is known as "brain drain", which is a term used by Saxenian (1999) in studies about the circulation of people between California (USA) and development countries, such as China and India. The movement of people between these countries was characterized by loss of qualified workers to USA. Nevertheless, in more recent articles, Saxenian (2002, 2005) shows evidence that these movements of people became a more complex process, known as "brain circulation". The Asian immigrants established many connections with agents in their native countries, such as frequent exchanges of information about technology, jobs, business opportunities, and also achievement of investments in startups and capital funds in their countries. Other studies that evaluated of mobility of workers use this concept to analyze the inflow and outflow of skilled people in one region (Miguélez & Moreno 2014; 2015).

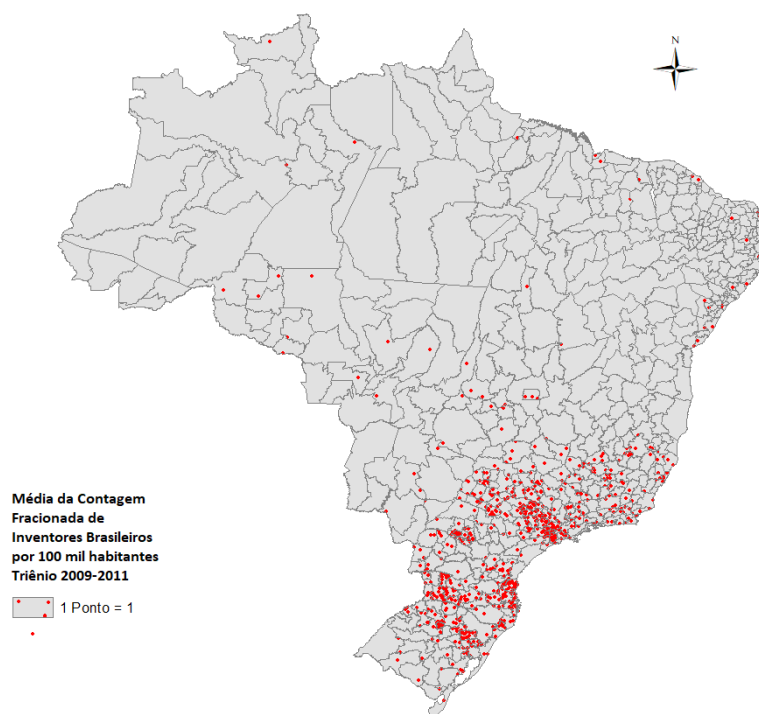
#### **Measure of Innovation:**





To evaluate if the skilled workers' mobility can influence the results of innovation it was used data from Patents in the National Institute for Intellectual Property (INPI) in the years of 2009, 2010 and 2011. This triennium has 26.744 inventors registered with consistent information about their localization. Brazil is a very large country and has many differences regarding the distribution of innovative activities (Albuquerque 2000). The number of inventor's patents had concentration in regions that have major level of economics activities: the regions South and Southeast. The Map 1 presents the concentration of distributions of inventor's patents per capita for micro-regions in the triennium 2009-2011.

Map 1 – Distribution of Average Inventor's Patents per capita for micro-regions (2009-2010-2011)



Source: Original Work, using data of National Institute of Industrial Property and Brazilian Institute of Geography and Statistics

### **Measure of Worker Mobility:**

To build the measures of Worker Mobility it was used data from Brazilian Ministry of Labor and Employment denominated RAIS ID. With these data, it was possible to follow the occupational trajectory of workers and to get information on



many of their characteristics. Each line of the database corresponds to a registration of an employment relationship in the year being analyzed, and relates this individual to one company and location. This line also contains the characteristics of the employment, such as remuneration, occupation, educational level, employment situation on December 31st, among others. There is also a code of Social Integration Program (PIS) for each worker. With this identifier it was possible to find a worker in different years if this worker was registered in formal employment throughout the years.

In this article the data used covers the years of 2003 to 2008, including the entire national territory. To build the measure of Worker Mobility, the SQL language was used for querying in a PostgreSQL database.

The first step was a selection of all records that have active link in December 31st 2008. If the same PIS had two or more active links in December 31st 2008, these records were discarded (that strategy can imply in losses, for example, when one worker have more than one job). The second step was a sectorial cut. This is necessary because not all sectors use the patent as a means of protection and other sectors don't innovate (for example, commercial and public administration). The selected sectorials are Agriculture, Extractive Industry and Manufacturing. In the database there are 8,460,882 records in selected activities, of which 479,479 (5.67%) of these workers have a higher education or above and 98.277 are in technical and scientific occupations (1,16%).

The mobility is the sum of workers in 2008 in micro-region "r" that came from another job (active in December 31st) and another micro-region through five-year time windows (2003-2008). Workers that have moved from one micro-region in 2006 to another micro-region in 2007 are not accounted for the mobility. Workers that have moved from one micro-region in 2006 to another micro-region in 2007 but moved again from one micro-region in 2007 to another micro-region in 2008 are accounted only once.

Additionally, three qualification measures of workers were used to evaluate if the mobility of workers can influence the innovation. It was calculated the mobility of the total workers (TO), the mobility of workers with higher education (HE) and the mobility of workers in technical and scientific occupations (TS) – which includes researchers, engineers, mathematicians, and others. The mobility of workers with higher education and in technical and scientific occupations was considered mobility of skilled workers.

Four mobility rates were used as proxies for Worker Mobility. The first one is the Inflow of Workers, i.e. the number of inflows workers to micro-region over the number of local workers in 2008. Others mobility rates were included: the Outflow of Workers is the number of outflows workers per number of local workers; the Net Mobility is the inflow minus the outflow divided by the numbers of workers; and Gross Mobility is the inflow plus outflow of workers over the number of local workers. These variables were included in different models in order to avoid collinearity problems.

Table 1 present the number of movements of workers by year and different qualifications.



**Table 1: Annual Workers' Mobility**

Years	Total Workers		Skilled' workers			
	Inflow	Outflow	Higher Education		Technical and scientific occupations	
			Inflow	Outflow	Inflow	Outflow
2003-2008	161.893	139.712	14.537	13.378	2.975	2.486
2004-2008	207.927	199.949	18.332	18.628	3.774	3.538
2005-2008	241.582	224.104	23.646	22.401	5.146	4.660
2006-2008	291.308	282.455	36.030	34.847	6.613	6.410
2007-2008	296.273	292.481	30.736	29.929	7.933	7.819
Total	1.198.983	1.138.701	123.281	119.183	26.441	24.913

**Source: Original Work**

It is possible to notice that in Brazil, between the years of 2003 to 2008, around 1.2 million inflows/outflows of total workers for other micro-regions took place, i.e., workers that changed the geographical localization of their work. The number of movements was lower for skilled workers - around 120 thousand for workers with higher education and 25 thousand for workers in technical and scientific occupations. Table 2 presents the percentage of workers that entered in a micro-region between the years of 2003-2008 divided by workers in selected activities (agriculture, extractive and manufacturing).

**Table 2: Workers' Mobility and composition of the local workforce**

		Inflow	% composition of the local workforce
Selected activities (Workers = 8.4 mi)	Total	1.198.983	14,2
	Higher Education	119.183	1,4
	Technical and scientific occupations	24.913	0,3

**Source: Original Work**

The composition of local workforce is 14,2% for total workers, 1,4% for workers with higher education and 0,3% for selected occupations. These percentages are compatible with the low number of Brazilian skilled workers. Even with this low participation of skilled workers, it is expected that their movements influence the results of innovation in the regional level.

Thus, it is expected that the Inflow and Net Mobility have significant and positive results; recent studies present the importance of mobility of workers as a source of knowledge flows (Breschi & Lissoni 2009; Gagliardi 2015; Fratesi 2014; Lenzi 2013). Furthermore, the Outflow and Gross Mobility are considered alternative source of knowledge flows due to the circulation of people and the possibility that these movements may generate benefits for the region – such as formal and informal connections with other regions, information exchange about technologies, occupations



and business. So, if the brain circulation is important, we expect the coefficient to be positive (Miguélez & Moreno 2015; Fratesi 2014; Saxenian 2002; 2005).

### **Empirical analysis:**

An empirical model was estimated using the dataset to investigate if the skilled workers' mobility can influence the results of innovation. The empirical strategy was based on the knowledge production function that estimates innovation measures as a function of regional factors (Griliches 1979; Jaffe 1989).

The dependent variable was measured using patent inventors per capita averaged across the years of 2009, 2010 and 2011 (Avg\_Patentpc). The patents were georeferenced by the localization of the inventors. The most important independent variable is mobility of workers for selected activities (WorkerMobility). These variables were lagged for the year of 2008 and were categorized across 3 different qualifications of workers: total (TO), higher education (HE) and in technical and scientific occupations (TS). For each qualification it was measured the Inflow, Outflow, Net Mobility and Gross Mobility.

Independent variables related to direct drivers of innovation and characteristics of region were added to the model. The variables related to the drivers of innovation were: the level of Research and Development (R&D) of local firms and the level of R&D in universities. The level of R&D (R&D\_local) in one region is an important indicator of the existence of local knowledge spillovers. The knowledge created in the firm can overflow the barriers of the firm and this can benefit other firms that are localized in the same region (Audretsch & Feldman 1996). The proxy used for R&D local is measured by the number of workers employed on R&D activities in 2008. Two occupations were selected: director of R&D (CBO 123705) and managers of R&D (CBO 142605).

The level of R&D in universities is also a variable that was inserted in the estimation. The universities have an important impact in basic research development. The sectors that are more complex, such as high-tech industries, have more benefits of this proximity (Cohen et al. 2002; Klevorick et al. 1995). Regions that have a high level of university research tend to have academic qualifications that are compatible with the needs of local businesses. The proxy used to measure the university R&D (R&D\_univ) was the number of PhD professors that were active and dedicated full-time per 10,000 inhabitants in 2009. The data of professors was made available by National Institute for Educational Studies and Research (INEP) linked to the Ministry of Education in Brazil in 2009. The data of population is from IBGE in 2008. Amongst the variables related with characteristics of region, the first one is a measure of the productive structure of region.

The Krugman specialization index (K-index) was used as proxy of productive structure. The K-index captures the degree of local specialization or diversification. In diversified regions the complementarity amongst activities is the basis for knowledge transfers. In this diversified region, there are greater opportunities for firms to imitate, share, and recombine ideas and practices across industries (Glaeser et al. 1992; Storper





& Venables 2004). The values of K-index vary from 0 to 2. Values that are closer to 0 indicates that the micro-region is more diversified and values closer to 2 indicates that the micro-region can be considered more specialized – according with one analyze base selected. Thus, it is expected that this variable is negatively correlated with the measure of innovation.

Others regional controls were added such as dummies for South and Southeast (SSE) and metropolitan areas (Metro). It was necessary to control these variables because the regional distribution of innovation is highly concentrated in these macro-regions of Brazil, but also in urbanized and agglomerated areas. Metropolitan areas are more dynamic. In these areas there is a labor market more leaning to attract firms and more qualified people, who are more involved in activities intensive in knowledge. These areas are agglomerated, so it has effects have important benefits for firms and other agents that are co-located. The proximity can generate knowledge spillovers through the dissemination of knowledge in local networks and facilities interactive learning process (Boschma et al. 2014; Carlino et al. 2007; Breschi & Lissoni 2001). The data of metropolitan areas are available in IBGE. Finally, other variables included in the estimation were the level of workers employed in agriculture, extractive and manufacturing activities on the regions (Share). These activities were the same selected to build the measure of mobility of workers.

The Tobit model was used. This model is a censored regression model and is indicated to estimate linear relationships when censoring data in the dependent variable exists. The measure of innovation uses the patent depositors and there are many micro-regions in Brazil that don't have a patent at the period analyzed (201 left-censored observations).

The estimated equation takes the following form:

$$\begin{aligned}
 Avg\_Patentpc_{2009a2011} &= \beta_0 + \beta_1 WorkerMobility_{2003-2008} + \beta_2 \ln(R\&D\_local)_{2008} \\
 &+ \beta_3 \ln(R\&D\_univ)_{2008} + \beta_4 K-index_{2008} + \beta_5 Metro_{2008} + \beta_6 SSE_{2008} \\
 &+ \beta_7 ShareManuf_{2008} + \beta_8 ShareAgri_{2008} + \beta_9 ShareExtrat_{2008} + \mu
 \end{aligned}$$

Table 3 present the description of the variables.



## IV ENEI

# Encontro Nacional de Economia Industrial e Inovação

### Inovação, Produtividade e os Desafios do Crescimento

**10 a 12 de setembro de 2019**

**Campinas, São Paulo**

**Table 3: Description of the variables**

	Variable	Description	Source
Variable Dependent <b>Innovation</b>	<i>Avg_Patentpc</i>	Patent inventors per capita averaged across the years of 2009, 2010 and 2011	Original work, using INPI (2009,2010,2011) and IBGE (2009,2010,2001)
	<i>Worker Mobility</i>	Mobility of workers per workers total in selective activities	Original work, using RAIS ID (2008,2007,2006)
	<i>R&amp;D_local</i>	Workers in R&D activities (directors and managers) per total of workers	RAIS ID (2008)
Variables Independent <b>Regional Characteristic</b>	<i>R&amp;D_univ</i>	Number of active, full-time PhD professors per 10,000 inhabitants	INEP (2009) and IBGE (2008)
	<i>K-index</i>	Krugman's specialization index for the micro-region	RAIS (2008)
	<i>SSE</i>	Dummy for South and Southeast Region	IBGE (2007)
	<i>Metro</i>	Dummy for Metropolitan Areas	IBGE (2010)
	<i>Share Manuf</i>	Share of Manufacturing firms	RAIS (2008)
	<i>Share Agri</i>	Share of Agriculture firms	RAIS (2008)
	<i>Share Extrat</i>	Share of Extractive firms	RAIS (2008)

**Source: Original Work**

### Results:

Table 4 represents the result of the Tobit Regression. Model 1 through Model 12 reports the estimations that relate innovation with the regional characteristics, which can influence regional innovation results. Each model presents the estimation with one measure of mobility of workers in order to avoid collinearity problems.



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10 a 12 de setembro de 2019

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**Table 4: Results of Tobit Regression**

Variables (n=558)	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
ln(R&DLocal <sub>2008</sub> )	0.150*** (0.0229)	0.130*** (0.0238)	0.136*** (0.0231)	0.147*** (0.0228)	0.136*** (0.0234)	0.142*** (0.0236)
ln(R&DUniv <sub>2008</sub> )	0.129*** (0.0190)	0.128*** (0.0189)	0.128*** (0.0189)	0.128*** (0.0191)	0.129*** (0.0189)	0.129*** (0.0190)
Kindex <sub>2008</sub>	-0.474*** (0.123)	-0.486*** (0.121)	-0.519*** (0.123)	-0.477*** (0.123)	-0.479*** (0.122)	-0.489*** (0.122)
Metro <sub>2008</sub>	0.0846 (0.0675)	0.0574 (0.0665)	0.0568 (0.0666)	0.0824 (0.0675)	0.0542 (0.0671)	0.0695 (0.0667)
SSE	0.598*** (0.0577)	0.606*** (0.0571)	0.606*** (0.0572)	0.603*** (0.0575)	0.597*** (0.0573)	0.600*** (0.0574)
ShareManuf <sub>2008</sub>	1.049*** (0.204)	1.070*** (0.202)	1.085*** (0.203)	1.022*** (0.204)	1.081*** (0.204)	1.053*** (0.204)
ShareAgri <sub>2008</sub>	-0.262 (0.312)	-0.318 (0.293)	-0.274 (0.295)	-0.303 (0.303)	-0.293 (0.295)	-0.323 (0.296)
ShareExtrat <sub>2008</sub>	0.0250 (1.055)	-1.433 (1.122)	-1.506 (1.135)	-0.238 (1.008)	-0.636 (1.020)	-0.668 (1.109)
Inflow_TO <sub>(2003-2008)</sub>	-0.328 (0.372)					
Inflow_HE <sub>(2003-2008)</sub>		7.415** (3.085)				
Inflow_TC <sub>(2003-2008)</sub>			17.31** (6.882)			
Outflow_TO <sub>(2003-2008)</sub>				-0.198 (0.296)		
Outflow_ES <sub>(2003-2008)</sub>					6.143** (2.999)	
Outflow_TC <sub>(2003-2008)</sub>						10.54 (11.57)
Constant	0.158 (0.160)	0.105 (0.156)	0.154 (0.156)	0.159 (0.162)	0.0825 (0.158)	0.130 (0.157)
Sigma	0.509*** (0.0196)	0.506*** (0.0194)	0.506*** (0.0194)	0.509*** (0.0196)	0.507*** (0.0195)	0.509*** (0.0195)
Pseudo R2	0.448	0.452	0.452	0.448	0.451	0.448
Variables (n=558)	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
ln(R&DLocal <sub>2008</sub> )	0.148*** (0.0229)	0.147*** (0.0228)	0.146*** (0.0227)	0.148*** (0.0228)	0.128*** (0.0238)	0.135*** (0.0234)
ln(R&DUniv <sub>2008</sub> )	0.130*** (0.0190)	0.130*** (0.0190)	0.130*** (0.0189)	0.128*** (0.0191)	0.128*** (0.0188)	0.128*** (0.0189)
Kindex <sub>2008</sub>	-0.484*** (0.122)	-0.484*** (0.122)	-0.509*** (0.123)	-0.472*** (0.123)	-0.481*** (0.121)	-0.511*** (0.123)
Metro <sub>2008</sub>	0.0752 (0.0666)	0.0757 (0.0666)	0.0653 (0.0666)	0.0869 (0.0679)	0.0488 (0.0669)	0.0582 (0.0667)
SSE	0.603*** (0.0576)	0.604*** (0.0576)	0.610*** (0.0574)	0.600*** (0.0576)	0.601*** (0.0570)	0.602*** (0.0572)
ShareManuf <sub>2008</sub>	1.037*** (0.206)	1.035*** (0.203)	1.061*** (0.203)	1.031*** (0.203)	1.090*** (0.203)	1.082*** (0.203)
ShareAgri <sub>2008</sub>	-0.347 (0.295)	-0.350 (0.296)	-0.316 (0.295)	-0.260 (0.312)	-0.290 (0.293)	-0.277 (0.296)
ShareExtrat <sub>2008</sub>	-0.243 (1.031)	-0.289 (1.046)	-0.790 (1.037)	-0.0870 (1.024)	-1.255 (1.077)	-1.449 (1.159)
Net_TO_c <sub>(2003-2008)</sub>	-0.00695 (0.282)					
Net_HE_c <sub>(2003-2008)</sub>		0.459 (3.175)				
Net_TC_c <sub>(2003-2008)</sub>			18.12** (8.388)			
Gross_TO_c <sub>(2003-2008)</sub>				-0.181 (0.198)		
Gross_HE_c <sub>(2003-2008)</sub>					4.522** (1.764)	
Gross_TC_c <sub>(2003-2008)</sub>						10.62** (4.878)
Constant	0.132	0.135	0.157	0.171	0.0786	0.144



## IV ENEI

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	(0.158)	(0.157)	(0.157)	(0.162)	(0.157)	(0.156)
Sigma	0.509*** (0.0196)	0.509*** (0.0196)	0.508*** (0.0195)	0.509*** (0.0196)	0.506*** (0.0194)	0.507*** (0.0195)
Pseudo R2	0.447	0.447	0.451	0.448	0.452	0.451

Standard errors are shown in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Source: Authors' own elaboration in Stata 14 Software

Through the mobility of workers it is possible to perceive that the inflow of workers with higher education (Model 2) and in technical and scientific occupations (Model 3) positively affect the results of regional innovation, which is in line with previous studies about the importance of mobility of skilled workers (Breschi & Lenzi 2010, Lenzi 2013, Maré et al. 2014, Gagliardi 2014, Boschma et al. 2014)

The inflow of workers in a region can generate positive impacts in two ways. The first one is related to a more dynamic labor market, with more opportunities and new source of tacit knowledge that can be accessed by formal labor market (Gagliardi 2014). The second impact is more indirect: it can occur with the new possibilities of externalities due the new human capital in a region (Gagliardi 2014). In this sense, the face to face contact is important, since its communications form turns possible the decrease of institutional and cultural barriers, generate influence over the process of socialization and screening, and reduce the incentives and coordination problems. It also increases the trust in the economics activities (Storper & Venables, 2004). Additionally, the positive effect of movement of workers is related to the skill of workers. The movement of people is important because the knowledge isn't only formal, it have a tacit component. The knowledge is derived by human actions, which include practices, learning, studies and interactions with other agents (Gertler 2007). The tacit part of knowledge is embedded in people, so the movement of people is a factor that facilities the sharing of tacit knowledge amongst different agents (Miguélez & Moreno, 2015). This result is corroborated by the fact that the inflow of total workers isn't significant (Model 1).

Furthermore, the gross mobility of skilled workers was positive and significant (Model 11 and Model 12). These results corroborate the importance of circulation of skills people on the region and the impact on the regional innovation. These results are consistent with the ones presented in Miguélez and Moreno (2015). Thus, this result is connected to the hypothesis that the movement of workers, on the regional level, can be an alternative source of knowledge flows, which can bring opportunities for the regions through the possibilities of interaction with different people by contacts formal and informal, and creation of networks (Saxenian, 2002; 2005).

Regarding variable controls, some variables are significant and have an expected result. The proxies for local R&D and university R&D were positive and significant. This result indicates that the greater proportion of employees in R&D activities in one region can generate more benefits to the region in terms of patents per capita. The measure of university R&D was positive and significant as well. The K-index has a negative value and is significant, which means that more diversified regions have more effects in the innovation measures by patents per capita in Brazil. Dummies for South and Southeast and share in manufacturing activities are positive and significant, as expected.





Another estimate was done in order to strengthen the results achieved. The mobility of workers can be quite concentrated, such as in economic activities, so there was a preoccupation of understanding the geographical distribution of the mobility of total workers and skilled workers (higher education's and technical and scientific occupations workers). It was necessary to confirm if the effect of mobility in innovation that was estimated was not just related with the movement of workers in the same metropolitan areas. This preoccupation became relevant, since the activities in metropolitan areas are quite agglomerated. The metropolitan areas are big cities with social and productive diversity. The interaction in these cities creates an environment which is more connected, allowing the exchange of knowledge that is more complex and is related with cutting-edge technologies (Duranton & Puga, 2001). Furthermore, the agglomerations effects are very relevant in metropolitan areas. The urbanization created more possibilities of matching of skilled workers and firms, benefits for knowledge flows between different activities, access to a big consumer market, and specialized services and infrastructure (Glaeser et al. 1992, Rodríguez-Pose & Crescenzi, 2008). All of these characteristics can reinforce the influence of these cities in movement of workers and in generate of innovation activities.

In this way, Table 5 presents the measures of workers mobility split in mobility that occurred between micro-regions that are classified in the same metropolitan area by IBGE (Intra-Metropolitan Areas) and mobility that occurred between different micro-regions (without the mobility of workers between micro-regions in the same metropolitan area).

**Table 5: Mobility of workers in selected activities**

<b>Total Workers</b>	<b>Entry</b>	<b>%</b>	<b>Exit</b>	<b>%</b>
Intra-Metropolitan Areas	206.598	17,2	187.045	16,4
Other Areas	992.385	82,8	951.656	83,6
Total	1.198.983	100,0	1.138.701	100,0
<b>Higher Education</b>	<b>Entry</b>	<b>%</b>	<b>Exit</b>	<b>%</b>
Intra-Metropolitan Areas	21.322	17,3	21.221	17,8
Other Areas	101.959	82,7	97.962	82,2
Total	123.281	100,0	119.183	100,0
<b>Technical and scientific occupations</b>	<b>Entry</b>	<b>%</b>	<b>Exit</b>	<b>%</b>
Intra-Metropolitan Areas	3.725	14,1	4.034	16,2
Other Areas	22.716	85,9	20.879	83,8
Total	26.441	100,0	24.913	100,0

**Source: Original Work, using data of RAIS ID**

Table 5 presents the percentage of mobility that occurred between micro-regions localized in the same metropolitan areas. These pairs of micro-regions correspond to around 17% for mobility of total workers and higher education workers, and for workers in occupations selected the percentage is around 14%. So it is possible to conclude that a relevant part of the movements is concentrated. Since the patent activities in Brazil and the movement of workers are concentrated, the estimation with movements of workers between all micro-regions may be biased. Due to the



concentration, the estimates may be producing a result that is related with a phenomenon that is characteristic of metropolitan regions.

Table 6 presents the results of additional estimations. In these estimations the measure of mobility of workers was created without considering the mobility of workers that occurred between micro-regions belonging to the same metropolitan area. For example: it was excluded the mobility of workers between the micro-region of São Paulo and Osasco, which are two geographically close large cities that have much interchange of workers. The results are very similar to the estimation that contains all movements of workers. It corroborates to the importance of mobility of skilled workers for the regional innovation in all Brazil.



## IV ENEI

# Encontro Nacional de Economia Industrial e Inovação

Inovação, Produtividade e os Desafios do Crescimento

10 a 12 de setembro de 2019

Campinas, São Paulo

**Table 6: Results of Tobit regression without the mobility of workers intra-metropolitan areas**

Variables (n=558)	Model 13	Model 14	Model 15	Model 16	Model 17	Model 18
$\ln(R\&DLocal_{2008})$	0.146*** (0.0228)	0.127*** (0.0234)	0.136*** (0.0230)	0.148*** (0.0227)	0.133*** (0.0232)	0.139*** (0.0234)
$\ln(R\&DUniv_{2008})$	0.130*** (0.0189)	0.123*** (0.0189)	0.126*** (0.0189)	0.131*** (0.0190)	0.126*** (0.0188)	0.127*** (0.0190)
$Kindex_{2008}$	-0.493*** (0.123)	-0.490*** (0.121)	-0.524*** (0.123)	-0.488*** (0.123)	-0.455*** (0.122)	-0.492*** (0.122)
$Metro_{2008}$	0.0870 (0.0684)	0.0909 (0.0660)	0.0711 (0.0661)	0.0822 (0.0683)	0.0991 (0.0666)	0.0833 (0.0665)
SSE	0.607*** (0.0577)	0.611*** (0.0569)	0.608*** (0.0571)	0.604*** (0.0574)	0.602*** (0.0569)	0.601*** (0.0573)
$ShareManuf_{2008}$	1.033*** (0.203)	1.084*** (0.201)	1.089*** (0.203)	1.048*** (0.204)	1.084*** (0.202)	1.061*** (0.203)
$ShareAgri_{2008}$	-0.409 (0.306)	-0.320 (0.291)	-0.268 (0.295)	-0.373 (0.300)	-0.312 (0.292)	-0.311 (0.295)
$ShareExtrat_{2008}$	-0.400 (1.026)	-1.734 (1.108)	-1.529 (1.109)	-0.238 (1.005)	-0.785 (1.018)	-0.859 (1.085)
$Inflow\_TO\_ExcMetro_{(2003-2008)}$	0.266 (0.366)					
$Inflow\_HE\_ExcMetro_{(2003-2008)}$		10.13*** (3.163)				
$Inflow\_TC\_ExcMetro_{(2003-2008)}$			19.35*** (6.722)			
$Outflow\_TO\_ExcMetro_{(2003-2008)}$				0.130 (0.291)		
$Outflow\_HE\_ExcMetro_{(2003-2008)}$					9.143*** (3.474)	
$Outflow\_TC\_ExcMetro_{(2003-2008)}$						17.71 (11.77)
Constant	0.112 (0.159)	0.0975 (0.155)	0.157 (0.156)	0.114 (0.162)	0.0394 (0.159)	0.126 (0.156)
Sigma	0.508*** (0.0195)	0.503*** (0.0193)	0.505*** (0.0194)	0.509*** (0.0196)	0.505*** (0.0194)	0.508*** (0.0195)
Pseudo R2	0.448	0.455	0.453	0.448	0.453	0.449
Variables (n=558)	Model 19	Model 20	Model 21	Model 22	Model 23	Model 24
$\ln(R\&DLocal_{2008})$	0.147*** (0.0228)	0.147*** (0.0228)	0.146*** (0.0227)	0.147*** (0.0228)	0.125*** (0.0235)	0.133*** (0.0232)
$\ln(R\&DUniv_{2008})$	0.130*** (0.0190)	0.130*** (0.0190)	0.130*** (0.0189)	0.131*** (0.0189)	0.123*** (0.0188)	0.126*** (0.0189)
$Kindex_{2008}$	-0.484*** (0.122)	-0.492*** (0.123)	-0.513*** (0.123)	-0.492*** (0.123)	-0.467*** (0.121)	-0.517*** (0.122)
$Metro_{2008}$	0.0749 (0.0666)	0.0726 (0.0667)	0.0621 (0.0666)	0.0884 (0.0692)	0.102 (0.0661)	0.0784 (0.0661)
SSE	0.603*** (0.0576)	0.605*** (0.0576)	0.610*** (0.0574)	0.606*** (0.0575)	0.607*** (0.0567)	0.605*** (0.0570)
$ShareManuf_{2008}$	1.033*** (0.205)	1.036*** (0.203)	1.064*** (0.203)	1.047*** (0.203)	1.098*** (0.201)	1.089*** (0.203)
$ShareAgri_{2008}$	-0.348 (0.295)	-0.352 (0.295)	-0.312 (0.295)	-0.406 (0.306)	-0.307 (0.290)	-0.267 (0.295)
$ShareExtrat_{2008}$	-0.272 (1.024)	-0.431 (1.046)	-0.798 (1.036)	-0.314 (1.008)	-1.561 (1.073)	-1.550 (1.125)
$Net\_TO\_ExcMetro_{(2003-2008)}$	0.0380 (0.290)					
$Net\_HE\_ExcMetro_{(2003-2008)}$		2.316 (3.626)				
$Net\_TC\_ExcMetro_{(2003-2008)}$			19.17** (8.483)			
$Gross\_TO\_ExcMetro_{(2003-2008)}$				0.135 (0.195)		
$Gross\_HE\_ExcMetro_{(2003-2008)}$					6.381*** (1.900)	
$Gross\_TC\_ExcMetro_{(2003-2008)}$						12.82*** (4.765)
Constant	0.135	0.147	0.161	0.103	0.0452	0.144



	(0.158)	(0.158)	(0.157)	(0.162)	(0.157)	(0.156)
Sigma	0.509*** (0.0196)	0.509*** (0.0195)	0.507*** (0.0195)	0.508*** (0.0195)	0.502*** (0.0193)	0.505*** (0.0194)
Pseudo R2	0.447	0.448	0.451	0.448	0.456	0.453

Standard errors are shown in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Source: Authors' own elaboration in Stata 14 Software

### Conclusion:

There is a literature that investigates the extent to which the presence of qualified human capital in the region can lead to greater possibilities for knowledge exchange among different agents (Fratesi 2014; Breschi & Lenzi 2010; Lenzi 2013). The analysis of the skilled workers' mobility for regions is a question that stimulates studies about the local knowledge base and its relation with innovation (Maré et al. 2014; Gagliardi 2015; Crescenzi & Gagliardi 2015). In this line, the aim of this research is to evaluate if the skilled workers' mobility can influence the results of innovation. The benefits generated by the skilled workers' mobility in a region can positively influence the innovative results of geographically nearby companies. The contribution of this research is present new empirical evidence on the role of skilled workers' mobility as an important source of knowledge flows. There is a lack of evidence about this theme (Maré et al. 2014; Gagliardi 2015; Crescenzi & Gagliardi 2015). Moreover, such analyzes are still scarce for developing countries with continental dimensions, such as Brazil.

The estimation pointed the importance of mobility of skilled workers (with higher education and in technical and scientific occupations) in selected economic activities for regional innovation. The results present that the benefits of circulation of skilled workers are related with a more dynamic labor market and the externalities due the new knowledge in a region. Additionally, it is possible to assert that the movement of workers (inflows and outflows), on the regional level, can be an alternative source of knowledge flows, which can bring opportunities for the regions through the possibilities of formal and informal interactions. It is important to note that the movement of workers is concentrated, as well as the economic and patenting activities. So, to understanding if the mobility of workers effectively affects regional innovation was excluded the movements of workers that have occurred inside the metropolitan regions. This evaluation was used to reinforcing the results of previous estimations.

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