# THE MOBILITY OF SKILLED WORKERS AND INNOVATION IN BRAZIL

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**Abstract**: There is a growing literature that investigates the extent in which the presence of qualified human capital in a region can lead to greater possibilities for knowledge exchange amongst different agents. Thus, the analysis of the workers' mobility is an important question to studies that relates knowledge flows and innovation. The aim of this article is to evaluate how the skilled workers' mobility can influence the results of innovation. This work contributes by presenting empirical evidence on the role of skilled workers' mobility as an important source of knowledge flows. The empirical strategy is based on the knowledge production function. The results pointed to a possible positive relationship between innovation and skilled workers' mobility.

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

Código JEL: D62, O15, O31

**Introduction**:
There is a growing literature that investigates the extent to which the presence of qualified human capital in a region can lead to greater possibilities for knowledge exchange among different agents by enriching 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).
The analysis of the characteristics and implications of workers' mobility for regions is a question that stimulates studies about the local knowledge base and its relation with innovation. Thus, workers' mobility is one of the mechanisms by which the intensity and concentration of knowledge flows increase, as well as being a key element to explain the geographical concentrations of innovative activities (Breschi & Lissoni 2009; Gagliardi 2015; Lenzi 2013).
However, 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). Along these lines, authors have studied 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 mobility trajectories of individuals that produce and possess knowledge.
In this perspective, the aim of this research is to evaluate how 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 (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. 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, which is measured by the average of patents per capita in 2009-2011, is the dependent variable. Skilled workers' mobility is one of the independent variables and is the regressor of interest. The measure of workers' mobility used data from the Brazilian Ministry of Labor which covers all formal labor market in the specified year. The results pointed to a possible positive relationship between innovation and mobility of skilled workers, but tests and new model specifications are still required to ensure statistics robustness.

This paper is organized as follows. The next section presents the main conceptual background relating mobility and innovation. Section 3 provides a description of the main variables of the model: the measure of innovation and the measure of skilled 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, limitations and the next steps of this research.

**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 persistent 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, have different types of knowledge that is not available in the population non-migrant, increase the knowledge diversity through the local interaction, have embodied knowledge and have access to people and networks in different places in the world (Maré et al. 2014). The interactions that contributes 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.

**Data:**

**Measure of Innovation:**

To evaluate how the skilled workers' mobility can influence the results of innovation, data from Patents Depositors in the National Institute for Intellectual Property (INPI) amongst the year of 2009 and 2011 was used. This triennium has 27.703 depositors registered. Of this total, 19.061 registers (68,8%) have consistent information about the depositors (information about the identification of depositors, physical or legal person and localization).

It is important to emphasize that the patent is not an exclusive appropriability mechanism (da Motta e Albuquerque 2000). Different sectors of the economy are related in different ways to the use of this mechanism. For example, there are sectors that differ in their propensity to patent and sectors in which patents are relevant. In some areas the complexity of production processes diminishes the appeal to patents as a safe mean of protection. However, it is a proxy widely used as a measure of the company's innovative results.

Brazil is a very large country and has many differences about the distribution of innovative activities (da Motta e Albuquerque 2000). Since it is a development country the number of depositors has concentration in regions that have major level of economics activities, for example: the regions South and Southeast1. The Figure 1 presents the distributions of depositor's patents per capita for micro-regions in the triennium 2009-2001.

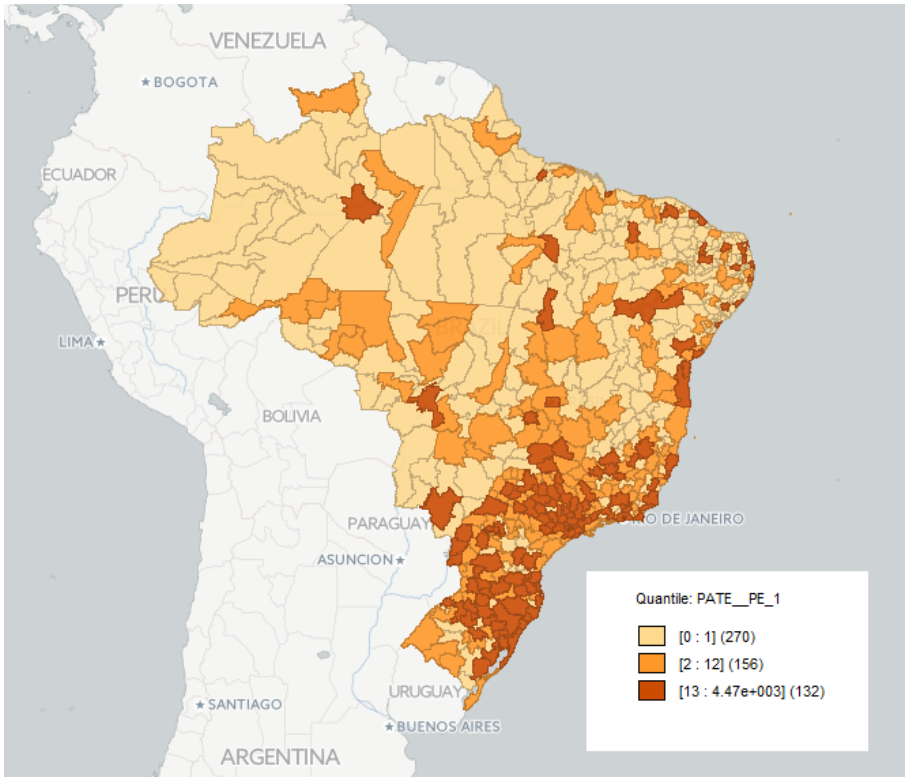


Figure 1 – Distribution of Average Depositor Patents per capita for micro-regions (2009-2010-2011)
Source: Original Works, using data of INPI and Brazilian Institute of Geography and Statistics (IBGE)

In absolute terms, the main micro-regions in number of patent depositors are metropolitan areas or micro-regions that are geographically close of these areas. The micro-region of the city of São Paulo has 23% of total. In terms of average patent depositor per capita, the micro-regions that stand out are the ones with medium-sized

[1] In terms of geography distribution, Brazil is a very large country. In the year of 2010, there were 5565 cities in Brazil. These cities were divided in 558 micro-regions, which are composed by 27 states. These states are aggregated in 5 regions (Northern, Northeastern, Center-Western, Southeastern and Southern). The level of aggregations used in this article is micro-regions.

cities. The Table 1 presents the ranking of the 10 micro-regions. It is observed that regions of South (S) and Southeast (SE) are more frequent in this analysis.

Table 1 – Ranking of 10 micro-region – Patent depositors (PD) and Patent depositors per capita averaged (PD pc avg) – Year 2009,2010,2011

| # | Region | Micro-region | PD | Total PD % | Region | Micro-region | PD pc avg |
|---|---|---|---|---|---|---|---|
| 1 | SE | São Paulo | 4466 | 0,23 | S | Caxias do Sul | 2,35E-04 |
| 2 | S | Curitiba | 1068 | 0,06 | SE | São Carlos | 1,98E-04 |
| 3 | SE | Belo Horizonte | 985 | 0,05 | S | Guaporé | 1,38E-04 |
| 4 | SE | Rio de Janeiro | 983 | 0,05 | S | Blumenau | 1,30E-04 |
| 5 | SE | Campinas | 815 | 0,04 | S | Joinville | 1,28E-04 |
| 6 | S | Porto Alegre | 807 | 0,04 | S | Não-Me-Toque | 1,26E-04 |
| 7 | S | Caxias do Sul | 539 | 0,03 | S | Chapecó | 1,22E-04 |
| 8 | SE | Osasco | 334 | 0,02 | S | Maringá | 1,20E-04 |
| 9 | S | Joinville | 318 | 0,02 | S | Curitiba | 1,14E-04 |
| 10 | CW | Brasília | 268 | 0,01 | SE | São Paulo | 1,08E-04 |

(N) Northern, (NE) Northeastern, (CW) Center-Western, (SE) Southeastern and (S) Southern

Source: Original Work, using BADEPI-INPI

**Measure of Worker Mobility:**

The measure of Worker Mobility used data from Brazilian Ministry of Labor and Employment denominated RAIS ID[2]. With this data it is possible to follow the occupational trajectory of workers, and get information of many characteristics of them. Each line of the base 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. In this base there is a code of Social Integration Program (PIS) for each worker. With this identifier it is possible to find a worker in different years if this worker was registered in formal employment throughout the years.

In this article, the data available covers the years of 2006 to 2008, including the entire national territory. To build the measure of Worker Mobility, SQL language was used for querying in a PostgreSQL database[3].

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). In 2008 there were 36.273.242 records in this condition (one single record for each PIS and active link in December 31st 2008). Of this total, 4,578,085

[2] The database available by Ministry of Labor is denominated Annual Social Information Relation (RAIS). This database have objective: to supply labor control needs in the country, provide data for the preparation of labor statistics and availability of labor market information to government entities (Source: http://rais.gov.br/sitio/sobre.jsf). RAIS provides information at the aggregate level, such as the region, economic activity, occupation, etc. RAIS ID provides the information at the individual level - through authorization for use and signature of the confidentiality term.

[3] PostgreSQL is a relational database management system free.

(12.6%) have a higher education or higher qualification (such as master's and doctoral degrees).

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 registers in these activities and 479,479 (5.67%) of these workers have a higher education or above. Thus, the follow scheme was adopted:

$$Worker\ Mobility_{r,2008} = \frac{\Sigma\left(Entry\ of\ skilled\ workers_{r,2008}\right) - \Sigma[\left(\ Exit\ of\ skilled\ workers_{r,(2007,2006)}\right)}{Total\ workers_{r,2008}}$$

$$Exit\ of\ skilled\ workers_{r,(2007,2006)} = \left(\ Exit\ of\ skilled\ workers_{r,2007}\right) + \left(Exit\ of\ skilled\ workers_{r,2006}\ \ not\ in\ Exit\ of\ skilled\ workers_{r,2007}\right)$$

Where "r" is a micro-region. The mobility is the sum of skilled workers in 2008 in micro-region "r" that came from another job (active in December 31st) and another micro-region in 2007 or 2006 (e.g., r2008 ≠ (r2007 or r2006)).

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.

The results for each micro-region are a difference between "Entry" and "Exit" of skilled workers divided by total workers analyzed. Each new PIS in 2008 is contabilized as "+1" (gain) for the micro-region in 2008. This same new PIS in 2008 is a lost PIS in 2007 and 2006 for another micro-region, thus, it is contabilized as "-1" (loss) there

**Estimation:**

An empirical model is estimated using this dataset to examine how the skilled workers' mobility can influence the results of 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).

The dependent variable was measured using patent depositors per capita averaged across the years of 2009, 2010 and 2011 (*Avg_Patentpc*). The most important independent variable is workers mobility (*WorkerMobility*) - this variable was lagged for the year of 2008. Independent variables related to characteristics of region and direct drivers of innovation were added to the model.

Amongst the variables related with characteristics of region, the first one is the productive structure of region. The Krugman specialization index (*K-index*) is a measure that captures the degree of local specialization or diversification[4]. In diversified

[4] The Krugman Index is calculated follows this equations:

$$K - index_i(t) = \sum abs\ (v^k_{i(t)} - v^{-k}_{i(t)});\ v^k_{i(t)} = \frac{x^{kt}_{i(t)}}{\sum_k v^k_{i(t)}}\ ;\ \text{and}\ v^{-k}_{i(t)} = \frac{\sum_{j\neq i} x^{kt}_{j(t)}}{\sum_k \sum_{j\neq i} x^{kt}_{j(t)}}$$

The term $v^k_{i(t)}$ correspond the participation of a sector *k* in the region *i* in all firms of this region. The term $v^{-k}_{i(t)}$ correspond the participation the same sector *k* in all the others regions different of *i* in relation the all firms in all regions different of *i*. O K-index is the difference modulo sum between this tow terms (Midelfart-Knarvik et al. 2000). The values of K-index are between 0 and 2, values close to 0 indicated

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 are between 0 and 2. Values close to 0 indicates that the micro-region is more diversified (according with the analyze base) and values close to 2 indicates that this micro-region can be considered more specialized. Thus, it is expected that this variable is negatively correlated with the measure of innovation.

Others regional controls were added. These variables are used to control factors that influence the attractiveness of local labor market such as population density (*Agglomeration*), metropolitan areas (*Metropolitan*) and unemployment rate (*Unemployment*).

The agglomeration 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 agglomeration was measured using the region's demography density, which was calculated using the population count in 2007 available in the IBGE divided by the total area of the micro-region in square kilometers, also available in IBGE.

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. The data of metropolitan areas are available in IBGE.

Lastly, the rate of unemployment was added. Regions that have higher level of unemployment tend to be less attractive for the firms and the employees. This data is one way to control the attractiveness of labor markets (Gagliardi 2015). The data of unemployment are available in Census of IBGE (2010). This is the more recent information about unemployment in the level of micro-regions. The rate of unemployment was the share of unemployed in the economically active population. It is expected that measures of Agglomeration and Metropolitan areas have a positive and a significant relationship with innovation and Unemployment have a negative relationship.

It was also added the variable related with the level of local and industrial R&D. The level of R&D 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 beneficiate other firms that are localized in the same region (Audretsch & Feldman 1996). The R&D local is measured by the average remuneration of workers employed direct with innovation in 2008 (*R&D_local*). The RAIS ID database has information about the occupation of the employee, based in Brazilian Classification of Occupations (CBO). Thus, the proxy for local efforts of R&D is the average of workers remuneration in 2008. Two occupations were selected: director of R&D (CBO 123705) and gerents of R&D (CBO 142605).

The level of university R&D 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 can be compatible with the needs of local businesses. The proxy used to measure the university R&D (*R&D_univ)* was the

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that the micro-region is more diversified (according with the analyze base), values close to 2 indicates that this micro-region can be considered more specialized.

number of PhD professors that were active and dedicated full-time per 10,000 inhabitants in 2009[5]. The data of professors was 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.

Another variable is the level of workers that are potentially employed in science and technology activities. The major participation of workers in these areas can influence more results in terms of innovative efforts (Crescenzi et al. 2007; Cohen & Levinthal 1990). All formal register in Ministry of Employer need to have an occupation, based in the Brazilian Classification of Occupations (CBO). The CBOs that were selected included researchers, engineers, mathematicians and others in RAIS ID[6]. Thus, the variable of occupation in technological and scientific activities (*Occupations_TS)* is the total of employees in these occupations divided by total of workers in the micro-region in 2008.

The estimated equation takes the following form:

$$\ln(Avg\ P_{Patentpc_{r,T}}) = \beta_0 + \beta_1 WorkerMobility_{r,t-1} + \beta_2 Kindex_{r,t-1} + \beta_3 \ln(Agglomertion_{r,t-1}) + \beta_4 Metropolitan_{r,t} + \beta_5 Unemployment_{r,t} + \beta_6 \ln(R\&D_{univ_{r,t-1}}) + \beta_7 \ln(R\&D\_local_{r,t-2}) + \beta_8 Occupation\_TS_{r,t-1} + \varepsilon$$

Table 2, Table 3 and Table 4 present the description of the variables, correlation matrix and descriptive statistics, respectively.

[5] The data are not available in 2008.

[6] Among the occupations listed are the following CBOs: 203 (researchers); 202 (mechatronics engineers); 214 (civil engineers, etc.); 222 (agronomic and fishing engineers); 1,237 (R & D directors); 1,426 (R & D managers); 201 (biotechnologists, geneticists, researchers in metrology and specialists in meteorological calibrations); 211 (mathematical, statistical and related); 212 (computer professionals); 213 (physical, chemical and related) and 221 (biologists and related).

Table 2 – Description of the variables

| | Variable | Description | Source |
|---|---|---|---|
| Variable Dependent Innovation | *Average Patent pc* | Patent depositors per capita averaged across the years of 2009, 2010 and 2011 | Original work, using INPI (2009,2010,2011) and IBGE (2009,2010,2001) |
| Variables Independent Regional Characteristic | *Worker Mobility* | Entry and exit of skilled workers/skilled workers total in selective activities | Original work, using RAIS ID (2008,2007,2006) |
| | *K-index* | Krugman's specialization index for the micro-region | RAIS (2008) |
| | *Agglomeration* | Population per area in square kilometers | IBGE (2007) |
| | *Metropolitan* | Dummy for Metropolitan Areas | IBGE (2010) |
| | *Unemployment rate* | Share of unemployed in the economically active population | Census IBGE, 2010 |
| Variables Independent Innovation Characteristics | *R&D_univ* | Number of active, full-time PhD professors per 10,000 inhabitants | INEP (2009) and IBGE (2008) |
| | *R&D_local* | Average expenditures on workers employed in R&D (directors and managers) | RAIS ID (2008) |
| | *Occupation_TS* | Share of employed in occupations technical and scientific per total employees | RAIS ID (2008) |

Source: Original Work

Table 3 – Correlation matrix

| | *Average Patent pc* | *Worker Mobility* | *K-index* | *Agglomeration* | *Metropolitan* | *Unemployment rate* | *R&D_univ* | *R&D_local* | *Occupations_TS* |
|---|---|---|---|---|---|---|---|---|---|
| *Average Patent pc* | 1.0000 | | | | | | | | |
| *Worker Mobility* | 0.0208 | 1.0000 | | | | | | | |
| *K-index* | -0.4300 | 0.1047 | 1.0000 | | | | | | |
| *Agglomeration* | 0.4126 | -0.1044 | -0.4755 | 1.0000 | | | | | |
| *Metropolitan* | 0.3515 | -0.0741 | -0.2841 | 0.4674 | 1.0000 | | | | |
| *Unemployment rate* | -0.1530 | 0.0502 | 0.0609 | 0.1877 | 0.1534 | 1.0000 | | | |
| *R&D_univ* | 0.2665 | -0.1381 | -0.3036 | 0.2457 | 0.3062 | 0.1323 | 1.0000 | | |
| *R&D_local* | 0.4191 | 0.0082 | -0.5272 | 0.4536 | 0.2523 | 0.1371 | 0.2845 | 1.0000 | |
| *Occupations_TS* | 0.3510 | 0.0642 | -0.2633 | 0.3654 | 0.3449 | 0.1988 | 0.2278 | 0.4040 | 1.0000 |

Source: Original Work

Table 4 – Descriptive Statistics

| Variable | Obs | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|
| *Average Patent pc* | 558 | .0000145 | .0000261 | 0 | .0002345 |
| *Worker Mobility* | 558 | .0000446 | .0050887 | -.0774487 | .0278137 |
| *K-index* | 558 | 1.174734 | .3271697 | 0 | 1.978673 |
| *Agglomeration* | 558 | 3.367837 | 1.380411 | .2504766 | 8.644855 |
| *Metropolitan* | 558 | .046595 | .2109589 | 0 | 1 |
| *Unemployment rate* | 558 | 3.837993 | 1.216615 | .83 | 9.75 |
| *R&D_univ* | 558 | .0002186 | .0005695 | 0 | .0042589 |
| *R&D_local* | 558 | 3.954413 | 4.270587 | 0 | 10.03366 |
| *Occupations_TS* | 558 | .0041098 | .004498 | 0 | .0371036 |

Source: Original Works

**Results:**

Table 5 represents the result of the Ordinary Least Squares (OLS) and the Tobit Regression.

Table 5 – Estimation results

| Dep. variable: *ln_Avg_Patent_pc* | OLS (1) | OLS (2) | OLS (3) | TOBIT (4) | TOBIT (5) | TOBIT (6) |
|---|---|---|---|---|---|---|
| *Worker Mobility* | 0.00051 | | 0.00041 | 0.00091 | | 0.00072 |
| | [3.99]*** | | [3.64]*** | [2.90]** | | [2.54]* |
| *K-index* | -0.00002 | | -0.00001 | -0.00004 | | -0.00003 |
| | [6.22]*** | | [3.39]*** | [8.66]*** | | [5.25]*** |
| *ln_Agglomeration* | 0.00000 | | 0.00000 | 0.00001 | | 0.00001 |
| | [6.46]*** | | [4.97]*** | [6.74]*** | | [5.02]*** |
| *Metropolitan areas* | 0.00003 | | 0.00002 | 0.00002 | | 0.00001 |
| | [3.31]*** | | [2.29]* | [2.79]** | | [1.78] |
| *Unemployment rate* | -0.00000 | | -0.00001 | -0.00001 | | -0.00001 |
| | [5.15]*** | | [6.33]*** | [5.94]*** | | [7.46]*** |
| *ln_R&D_univ* | | 0.00623 | 0.00452 | | 0.00834 | 0.00624 |
| | | [1.70] | [1.22] | | [3.48]*** | [2.83]** |
| *ln_R&D_local* | | 0.00000 | 0.00000 | | 0.00000 | 0.00000 |
| | | [7.16]*** | [4.43]*** | | [9.11]*** | [4.84]*** |
| *Occupations_TS* | | 0.00115 | 0.00090 | | 0.00135 | 0.00095 |
| | | [3.48]*** | [3.54]*** | | [4.07]*** | [3.06]** |
| *Constant* | 0.00004 | 0.00000 | 0.00003 | 0.00005 | -0.00002 | 0.00003 |
| | [6.94]*** | [1.12] | [5.47]*** | [5.99]*** | [6.90]*** | [3.98]*** |
| Sigma *_Constant* | -- | -- | -- | 0.00003 | 0.00003 | 0.00003 |
| | | | | [26.08]*** | [25.90]*** | [26.21]*** |
| $R^2$ | 0.32 | 0.23 | 0.38 | | | |
| *N* | 558 | 558 | 558 | 558 | 558 | 558 |

Note: Robust standard errors in parentheses; * p<0.05; ** p<0.01; *** p<0.001
Source: Original Work

Column 1 reports the results that relate innovation with the regional characteristics. All variables are significant and have a signal according to expected. Highest levels of agglomeration and metropolitan areas have a positive effect in the innovation for one micro-region. This result corroborates with the argument about the agglomeration effects. The effects of agglomeration are important for firms and other agents that are located nearby, enabling the dissemination of knowledge in local networks and facilities interactive learning process. The unemployment has a negative effect in results of innovation, as expected. Regions with major level of unemployment are characterized as less dynamic. These regions have worse conditions to develop and attract innovative enterprises. The K-index has a negative value and is significant. More diversified regions have more effects in the innovation measures by patents per capita. The worker mobility also has a positive and significant coefficient. Micro-regions that have a major percentage of this indicator of mobility have positive effects in the innovation. The entry of skilled workers, without the loss of another one, enriches the local knowledge base. This can lead to greater possibilities for knowledge exchange among different agents.

Column 2 reports the results that related innovation with the direct drivers that influence innovation, investments in R&D and employees in these activities. Both R&D industrial and occupations in science and technology activities are positive and significant. This result indicates that the greater proportion of these employees in one region can generate more benefits to the region in terms of patents per capita. Additionally, higher spending on R & D personnel (here measured by R&D_local) is better for other firms localized in this region. The measure of university R&D was positive, but is not significant. Column 3 reports the results that relate innovation with all independent variables. All variables maintain the significance and sign of the effect.

Another strategy of the estimation was the use of a Tobit model. 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). Again, 3 regressions were estimated.

The Column 4 presents the Tobit regression with only the variables that are related with region. In this estimate the variable of Workers Mobility lose some of the significance, down to 1%. The Column 5 presents the results that relate innovation with the direct drivers that influence innovation, R&D industry and university and employees in scientific and technological occupations. All variables are positive and significant. In this estimation the variable of university R&D is significant. This result is more compatible with others studies that indicate the importance of universities in the innovative activities in Brazil (Suzigan et al. 2009; Rapini et al. 2009; Suzigan & Albuquerque 2011; Fernandes et /al. 2010). The Column 6 presents Tobit regression with all variables. The metropolitan areas and Workers Mobility lose significance. Workers Mobility is only 5% significant. This result needs to be more investigated. The lack of significance in this variable can occur because this phenomenal really does not have significance for the innovation in Brazil or because this variable is not appropriate to measure this effect, since the model Tobit seems to be most appropriate for the type of dependent variable used.

**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 how 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 empirical strategy is based on the knowledge production function that estimates innovation measures as a function of regional factors (Griliches 1979; Jaffe 1989). The model Tobit seems to be the most appropriate for analysis the data of Patents in the micro-regions in Brazil. In Brazil many micro-regions don't have depositors patents registered in INPI (company or person).

This estimation by OLS indicates that exists one relation between innovation and skilled workers' mobility, but the result loses significance when the Tobit model is estimated. Thus, some limitations should be pointed out. It is necessary to investigate the magnitude of the results presented in this article, to measure better this effect. Also it is necessary to test different measures of mobility and innovation, mainly those related with the lagged time used. It is interesting to observe how the results vary according to the specification of these two variables.

Another point to be highlighted is the possible endogeneity problem that may exist between the innovation and mobility variables. This problem involves the fact that the innovative performance of a region can also influence the attraction of skilled workers to that region. The capability of the region to attract skilled workers is linked to its dynamism, which creates a more dynamic labor market in which new employment opportunities are created. Thus, this fact points to a possible problem of simultaneity between the two presented variables (Gagliardi 2015; Crescenzi & Gagliardi 2015; Maré et al. 2014). One approach that may be necessary is the use of instrumental variable to mitigate this problem. These points will be addressed in this research.

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