



# Estimating Vacancies from Firms' Hiring behavior: The Case of a Developing Economy<sup>\*</sup>

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## Abstract

Vacancies are the center of any job creation process. In this paper, we study firms' hiring behavior in a way that is directly related to vacancies. To understand the dynamic relationship between hires and vacancies, we estimate what we called a hiring function. Even though we cannot observe vacancies in our data, we propose an original procedure that allows recovering an estimate of vacancies. For this purpose we use firms' standard information on hires and separations. Monte Carlo experiments show that the prediction of vacancies from this procedure is consistent. Using this prediction, we analyze the firm and aggregated level behavior of vacancies for the Colombian labor market. We find that 73% of all vacancies are created by large firms but, relatively, small firms create more new positions. The method we propose may be useful in developing economies, where there are no good sources of information on vacancies.

## Resumen

A pesar de que las vacantes son el núcleo de cualquier proceso de creación de trabajo, estas han quedado en un segundo plano en el análisis tradicional de la dinámica del mercado laboral. La razón para esto puede ser la dificultad de contar con información que al mismo tiempo combine flujos de trabajadores y vacantes. En este estudio, nosotros analizamos la contratación de las firmas, de forma tal que es directamente asociada a las vacantes. Para entender la relación dinámica ente contrataciones y vacantes se estima una función de contratación. A pesar de que las vacantes no se observan en los datos administrativos usados en este estudio, se propone una metodología original para estimar las vacantes, usando para este propósito información sobre contrataciones, separaciones y el nivel de empleo de la firma. Experimentos Monte Carlo confirman que bajo supuestos estándar, es posible estimar las vacantes de forma consistente. Usando la predicción de stock y flujo de vacantes, este estudio analiza relaciones fundamentales entre vacantes, contrataciones y nivel de empleo para el mercado laboral Colombiano. La metodología que proponemos puede ser especialmente útil para países en desarrollo, donde no hay información disponible sobre vacantes.

**JEL Classification Codes:** J60, J63, J23

**Keywords:** Turnover, Vacancies, Layoff, Labor Demand, Labor Force and Employment.

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## **1. Introduction**

Vacancies are an essential element in the process that determines worker and job flows; they are the only source for hires, which simultaneously with separations explain the changes in the employment of firms, sectors and entire labor markets. In the theoretical literature, vacancies play an essential role in Equilibrium Unemployment Theory models; together with unemployment, vacancies are the attributes of matching functions, the most salient theoretical innovation of search models. Despite the importance of vacancies in theoretical models and its critical influence in the determination of a firm's labor stock, relatively few empirical studies analyze vacancies, and its relation with hires and separations at the establishment level, (Davis S. J., 2013). Most of the studies on vacancies use data from a few developed countries, where information on firms' open positions is available. Even for the countries with the best information available, what is known about vacancies and its relationship with worker and job flows pales in comparison with what is known about other labor market variables such as participation or unemployment (Davis S. J., 2013).

In the case of developing countries, the literature on vacancies is even scarcer, however, several studies attempt the construction of vacancy indexes, using for this purpose the number of Help Wanted advertisement posts in newspapers (Arango, 2013; Alvarez, 2014). For some countries, this is the only way to measure vacancies, given the absence of official sources of information on the matter (Alvarez, 2014). A series of issues with this type of vacancies measurement has been identified in the literature. Some studies suggest that job vacancies based on Help Wanted ads may capture the movements and dynamics of real vacancies (Amoah, 2000; Abraham & Wachter, 1987); nevertheless, it would be impossible for that methodology to capture the level of the real job vacancies, and therefore, the actual level of the vacancy rate. An additional issue with the Help Wanted ads is that in recent times, with the popularization of the internet, posting ads in written newspapers is a less frequent practice. There are corrections suggested in the literature to deal with this problem.

The empirical literature on the dynamics of workers and jobs is wide, especially in developed countries, where there are sources of information that allow the measurement of worker and job flows with precision (Davis, et al. 1996; Burgess, 2000; Morales and

Medina, 2016). Nevertheless, in most of the studies, vacancies are implicit in the workers and job flows analyzed, and they do not play a direct role in the intensity of job and worker movements. The traditional measures of flows in the labor markets are worker reallocation (separation plus hires), job reallocation (job creation plus job destruction) and churning (worker reallocation minus job reallocation)<sup>4</sup>. In the traditional view, vacancies implicitly show up as a fraction of job creation, since expanding firms are filling their vacancies, or as a fraction of churning because new hires can refill some open positions caused by separations. Even though vacancies are the center of any job creation process, they are relegated to an almost unnoticeable place in the analysis of labor worker and job dynamics. This is the case, perhaps, because of the difficulty of linking data sources that allow for the analysis of job and worker flows and vacancies at the same time.

Firms are constantly facing the problem of reaching their desired size and, as we propose in a theoretical framework in a further section, they have mainly two tools to do so: layoffs and vacancies. In regards to vacancies, on the one hand, they play an active role in determining job flows, in the sense that job creation is a process that has its roots in the firm's desire for creating new positions. On the other hand, vacancies also play an active role in determining worker flows; of all separations, in general, there is always a fraction that firms may need to replace, usually quits or re-evaluations of job matching by the firm. In both of the previous cases, there is an unwanted reduction in the size of a plant. This share of separations translates into vacancies that eventually will need to be filled; the proportion of all separations that is not translated into vacancies immediately turns into job destruction. Therefore, vacancies are directly linked to job creation when they are created for new positions; we will refer to this type of vacancies as expansion vacancies. In addition, vacancies are directly linked to labor churning as well, in the sense that all revisions of the job matching will be translated to a vacancy when it is not optimal for the firm to reduce its size by eliminating that position; we will refer to this type of vacancies as replacement vacancies.

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<sup>4</sup> “Worker reallocation (*WR*) refers to the number of workers who change labor status (Employed/Unemployed) during a period (Davis et al. (1997)), which is given by:  $WR_t \equiv H_t + S_t$ . The job reallocation (*JR*) refers to the number of jobs that are created and destroyed, which is given by:  $JR_t \equiv JC_t + JD_t$ .” (Flórez, Morales, Medina, & Lobo, 2017)

In this paper, we adopt a somewhat unusual view of the concept of vacancies, in which they play a more direct and meaningful role in the process that governs workers and job movements. We do this by modeling a hiring function that depends on separations and expansion vacancies. We justify the importance of a hiring function in a theoretical framework in which firms solve their dynamic optimization problem, using variables layoffs and expansion vacancies as a control to determine their optimal size. For our empirical work, we use an employer-employee linked panel from Colombia. As in many developing countries, there is no reliable information on vacancies in Colombia; nevertheless, using the idea of a hiring function, we propose a procedure that allows the researcher to recover an estimate of vacancies; using for this purpose standard employer-employee linked panel information, such as hires, separations and employment levels.

We evaluate the performance of our vacancies-prediction procedure using Monte Carlo experiments. We show that as long as the specification of the hiring function is dynamically complete, it is possible to obtain a consistent estimation of flows and stocks of replacement, expansion and total vacancies. We apply this vacancies-prediction procedure to real Colombian data. We get a reasonable estimation of aggregated vacancies, which behave realistically in the context of the formal Colombian labor market during the period from July 2008 to June 2016. The relationships of the estimated vacancies-stock with hiring and employment growth are, in several scopes, similar to the evidence shown by studies using actual data on vacancies from other countries. Furthermore, some of our vacancies related measures, such as the ratio of hires to vacancies, for instance, seems to be more stable, according to theory predictions, than previous estimations using raw data on observed vacancies. As previous studies remark, vacancies collected directly from firms can be the subject of measurement and aggregation problems, which complicates the inference of economic relationships between vacancies and other variables using raw data from these sources (Davis et al., 2013).

The estimation of vacancies from the firm's hiring behavior allows for a deeper understanding of the concepts of job creation and destruction. Traditional measures of job flows are mere proxies for real processes of job creation and destruction. Not necessarily all destructed jobs are reflected in firms' net employment change, because, for a particular

period, employment change could be determined by hires driven by worker replacements. New hires can also be motivated by the creation of new additional positions in the same or previous periods. For these and other reasons, a firm might have destroyed job positions in months of positive net growth. In the same way, the magnitude of job creation is not necessarily described precisely by firms' employment growth because, for a given period, hires that causes employment growth may be the result of worker replacement from previous separations. Hires may also be the result of the generation of new additional positions in the past, which, given frictions in the market, have not been filled yet.

The limitations of job flows have been remarked previously in the literature using the following paradox first proposed by Davis et al. (1996) "some newly created and newly destroyed jobs may not show up as plant-level employment changes. For example, a plant may destroy ten assembler jobs and create ten robotics technician jobs, so that total employment does not change." It is our belief that the methodology we propose in this paper is a step forward in expressing job flows in a way that the contradiction previously described is to some extent reduced. We divide vacancies in replacement and expansion vacancies, and we get an estimate of each one's stock and flow; therefore, we can distinguish creation of new positions and employment growth as two different phenomena. In addition, in our framework, destruction of job positions is, in a sense, the complement of replacement vacancies; from the establishment point of view, job destruction implies that some separated workers are never replaced. Therefore, we can distinguish destruction of previously existing job positions and employment reductions as two different phenomena, as well.

An estimation of the vacancies-stock allows us to perform a description of the relationship of vacancies with many labor market variables for the Colombian economy. At the labor market aggregate level, we analyze the relationship between vacancies and unemployment. Using data for the 23 main metropolitan areas in Colombia, we proposed labor market tightness index using the ratio between estimated vacancies-stock and unemployment at the level of metropolitan areas. The monthly series of vacancies computed in this paper are publicly available at <https://sites.google.com/site/leonardomoraleszurita/home/researchlm>.

In the second section of this paper, we describe a theoretical framework that justifies the use of a hiring function. In the third section, we propose a simple model of firms' hiring behavior, and we describe a methodology that allows predicting vacancies from firms' hiring behavior. In the fourth section, using Monte Carlo experiments, we evaluate the performance of the vacancies-prediction procedure. In the fifth section, we apply the vacancies-prediction procedure using Colombian data and get an estimation of the formal labor market vacancy-stock. In the sixth section, we analyze the establishment level behavior of vacancies, hires, and separations. In the seventh section, we estimate a labor market tightness index at the metropolitan area level. In section eight we comment on the sensitivity of our vacancies prediction to different distributional assumptions, and finally offer conclusions and some implications for policy.

## **2. Theoretical Framework**

In this section, we set up a theoretical framework, which is beneficial for the understanding of the empirical relationship we analyze in further sections. From the firm's point of view, flows of separations, hires and expansion vacancies are derived from the solution to the maximization-of-profits optimization problem. The traditional economic view establishes that firms in competitive markets are committed to maximizing their profits subject to a technological restriction. Standard approaches to the firm's problem consider labor as a homogeneous input, and the stock of workers as the control variable the firm chooses for the maximization of profits. As previous literature has pointed out, in a model with homogeneous labor the following will not occur at the same time for a single firm: vacancies, hires, and temporary layoffs (Holt, 1966); this is because no hires or vacancies are necessary if it is optimal for the firm to reduce its size. Data from real firms shows that shrinking firms have a good deal of hiring (Davis and Haltiwanger, 2014); this evidence is observed in developing economies as well (Morales and Medina, 2016). Therefore, in this framework, we consider several types of labor, each one with different wage rates. The classical approach to the firms' problem does not consider that there are frictions in the labor market; as a result of congestion in the market, firms may not be able to reach their desired size immediately. In this framework, we take into account frictions in the market by

introducing a hiring function, which determines the firms' hires as a function of the stock of vacancies.

In this framework, a firm decides the amount of separations and expansion vacancies subject to a technological restriction and subject to a firm's hiring function  $h_t^j(\cdot)$ , which maps the stock of vacancies to hires at a particular period. By deciding separations and vacancies, firms control their desired employment size each period. At the beginning of a given period  $t$  firms know the employment stock at the end of the previous period  $e_{it-1}^j$ , in addition, firms realize that some of the employees that belong to the last period employment stock leave voluntarily, this amount is represented by  $\hat{s}_{it}^j$ . Each period, a firm has to make decisions on separations ( $\check{s}_{it}^j$ ) and expansion (new) vacancies  $\vartheta_{it}^j$ , for each type of labor input  $j$ . The profit function<sup>5</sup> of a firm in a competitive market, in a given period  $t$ , can be represented as:

$$\pi_{i,t} = p_t \cdot f(e_{it}^j) - \sum_{j=1}^J w_t^j \cdot e_{it}^j \quad (1.1)$$

$$\text{where, } e_{it}^j = e_{it-1}^j - \hat{s}_{it}^j - \check{s}_{it}^j + h_t^j(\hat{s}_{it}^j, \vartheta_{it}^j, V_{it-1}^j) \quad (1.2)$$

In the previous equations,  $e_{it}^j$  stands for the amount of labor available for production at the end of period  $t$ ; equation (1.2) describes the dynamics of the stock of each labor type in a firm. Firms must optimally decide  $\check{s}_{it}^j$  and  $\vartheta_{it}^j$  taking into account that they start the period with  $\hat{s}_{it}^j$  fewer employees. We assume that since  $\hat{s}_{it}^j$  were quits, firms want to replace those positions. Firms will increase  $\check{s}_{it}^j$  if they find reducing their size to be optimal; firms may increase expansion vacancies  $\vartheta_{it}^j$  if they find increasing the size of the firm to be optimal. The expression  $h_t^j(\hat{s}_{it}^j, \vartheta_{it}^j, V_{it-1}^j)$  represents the firm's hiring function, which determines the firm's hires. Since there are frictions in the labor market, firms may not be able to fill all vacancies in a given period, therefore, in general  $h_t^j(\cdot) \leq \hat{s}_{it}^j + \vartheta_{it}^j + V_{it-1}^j$ ; for this reason,

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<sup>5</sup> For easiness in the notation, we ignore capital inputs; the production technology of the firm is a function of all types of labor.



the hiring function depends on the stock of vacancies that, at the end of the previous period, had not been filled yet  $V_{it-1}^j$ .

From the solution of its dynamic optimization problem, a firm obtains policy functions  $\check{s}_{it}^{j*}, \vartheta_{it}^{j*}$ , which are sequences of optimal choices for the control variables. The optimal hiring behavior is given by  $h_t^j(\hat{s}_{it}^j, \vartheta_{it}^{j*}, V_{it-1}^{j*})$ , where  $V_{it}^{j*}$  is the stock of vacancies derived from the optimal controls for separations and expansion variables ( $\check{s}_{it}^{j*}, \vartheta_{it}^{j*}$ ). In this model, the traditional measures of worker and job flows in the empirical literature: hires, separations, job creation, and job destruction, will be represented by:  $\sum_j h_t^j, \sum_j (\check{s}_{it}^j + \hat{s}_{it}^j), \sum_j 1_{\{\Delta e_{it}^j > 0\}} \Delta e_{it}^j, \sum_j 1_{\{\Delta e_{it}^j < 0\}} \Delta e_{it}^j$ , respectively.

There are three important takeaways from this section, which we will take into account in our empirical estimations. First, vacancies play a fundamental role in the dynamics of worker and job movements. Second, hiring behavior is the link between plant size and vacancies, and it is affected by rigidities of the labor market; therefore, in general, firms cannot reach their desired size instantaneously. Analyzing firm's hiring behavior, represented by the function  $h_t^j(\hat{s}_{it}^j, \vartheta_{it}^{j*}, V_{it-1}^{j*})$ , is crucial for the understanding of fluidity of labor inputs at the level of the firm. Third, in the analysis of firm hiring behavior, there should be a clear distinction between replacement vacancies and expansion vacancies; even though both determine hires they can be governed by different dynamics. In the next section, we propose a simple empirical strategy to estimate the  $h_t^j$  function; this will allow us to get an estimation of the flows and stocks of vacancies for each firm in the economy.

### **3. A Simple Model of Firm's Hiring Behavior.**

#### **3.1 A Model of the firm's hiring behavior.**

The total amount of vacancies of a firm is the result of two elements. On the one hand, the share of all firm's separations is replaced eventually after these separations take place; in other words, there are some vacancies that firms open with the purpose of replacing workers that are gone. On the other hand, there are vacancies that firms open for expansion purposes. The first type of vacancies does not imply job creation, they are an important

component of the churning rate, and we will refer to them as replacement vacancies. The second type of vacancies is the primary source of job creation, and we will refer to them as expansion vacancies. In this model, no vacancy is discarded without being filled, and all hiring has the purpose of filling a previously open vacancy.

Let us denote by  $s_t$  the total number of separations that take place in a firm during period  $t$ . On average, firms substitute a fraction of all separations, we assume this portion is constant, and we denote it as  $\pi$ ; therefore,  $\pi s_t$  represents the total number of separations generated in period  $t$  that will eventually be replaced. In other words, the total replacement vacancies that are caused due to separations  $s_t$  are  $\pi s_t$ . The hiring behavior of the firm is modeled in a simple way, in regards to replacement vacancies firms will hire  $\pi s_t$  workers from replacement vacancies generated at period  $t$ , but due to congestion in the labor market, it will take several periods for the firm to fill in these  $\pi s_t$  positions. The dynamics of this hiring behavior is modeled using a lags polynomial, the period  $t$  hires that correspond to the filling of replacement vacancies are represented as follows:

$$h_t^r = \sum_{\tau=0}^L \tilde{\theta}_\tau (\pi s_{t-\tau}) = \sum_{\tau=0}^L \theta_\tau s_{t-\tau} \quad (3.1)$$

$$\text{where, } \sum_{\tau}^l \tilde{\theta}_\tau = 1, \quad \sum_{\tau}^l \theta_\tau = \pi$$

The term  $\theta_\tau$ , which is equivalent to  $\pi \tilde{\theta}_\tau$ , accounts for the proportion of all replacement vacancies generated in a previous (or current) period  $\tau$  that are filled in the current period, and therefore, they become hires.

In regards to the expansion vacancies, they represent the creation of jobs at the level of the firm. From the maximization of profits, firms determine their optimal usage of the labor factor; if the demand for labor is smaller than the current size of the firm, it is optimal for the firm to expand and new expansion vacancies will be created. As before, due to congestion in the labor market, it will take several periods for the firm to fill these new positions. The period  $t$  hires that correspond to the filling of expansion vacancies are represented as follows:

$$h_t^e = \sum_{\tau=0}^R \phi_{\tau} \vartheta_{t-\tau} \quad (3.2)$$

where  $\sum_{\tau=0}^R \phi_{\tau} = 1$

The term  $\phi_{\tau}$  accounts for the proportion of all expansion vacancies generated in previous (or current) periods  $\tau$  that are filled in the current period, and therefore, they become hires. For instance,  $\phi_0 \vartheta_t$  represents the number of expansion vacancies generated at the current period  $t$  that are filled in the same period; the term  $\phi_1 \vartheta_{t-1}$  represents the amount of expansion vacancies generated at the previous period that are filled in the current period  $t$ .

In both types of vacancies, replacement or expansion, the length of the polynomial (L and R, respectively) determines the total amount of periods that it takes for vacancies generated in a given period to be filled. The most frequent data source for the studying of hires and separations are administrative records, which can be subject to measurement error. We include a measurement error term  $\epsilon_t$ , which is assumed is random. The vacancies that are filled at period  $t$ , and therefore become hires, are represented by the following hiring function:

$$h_t = \sum_{\tau=0}^L \theta_{\tau} s_{t-\tau} + \sum_{\tau=0}^R \phi_{\tau} \vartheta_{t-\tau} + \epsilon_t \quad (3.3)$$

where,  $\epsilon_t \sim N(0, \sigma_e)$

At a given period, the number of vacancies in a firm is the sum of all those positions that have not been filled yet. For instance, the stock of expansion vacancies consists of vacancies that were generated in previous periods, but that have not been filled completely. The following expression can represent this stock of expansion vacancies at the end of period  $t$ :

$$V_t^e = (1 - \phi_0 - \phi_1 - \dots - \phi_{R-1}) \vartheta_{t-R-1} + (1 - \phi_1 - \dots - \phi_{R-2}) \vartheta_{t-R-2} + \dots + (1 - \phi_0) \vartheta_t \quad (3.4)$$

The first term of equation 3.4 expresses the fact that at period  $t$  most of the expansion vacancies generated at period  $t - R - 1$  have already been filled, but there is a fraction

$\phi_R = 1 - \phi_0 - \phi_1 - \dots - \phi_{R-1}$  that has not been filled yet and it will be filled the next period. This is because on average, the firms fill all expansion vacancies in  $R$  periods. As the reader can notice, there are no vacancies generated in period  $t - R$  still unfilled, which is why there is not a  $\vartheta_{t-R}$  term included in equation 3.4. Following the same logic, the last term of equation 3.4 represents the fact that at time  $t$  the only vacancies generated at that period that have been filled are  $\phi_0 \vartheta_t$ . Analogously, the stock of replacement vacancies can be represented by the following equation:

$$V_t^r = (\pi - \theta_0 - \theta_1 - \dots - \theta_{L-1})s_{t-L-1} + (\pi - \theta_0 - \theta_1 - \dots - \theta_{L-2})s_{t-L-2} + \dots + (\pi - \theta_0)s_t \quad (3.5)$$

The first term of equation 3.5 expresses the fact that at period  $t$  there is a fraction  $\theta_R = \pi - \theta_0 - \theta_1 - \dots - \theta_{L-1}$  of replacement vacancies that have not been filled yet, and as in the case of expansion vacancies, it will be filled the next period. The last term of equation 3.5 represents the fact that at time  $t$  the only replacement vacancies generated from contemporaneous separations that have been filled are  $\theta_0 s_t$ .

The flow of expansion vacancies is the number of these vacancies generated at a given period, and it will be denoted as  $v_t^e = \vartheta_t$ . The flow of replacement vacancies at a given period is the number of the separations that will be replaced in that period or the future period, and it will be denoted as  $v_t^r = \pi s_t$ . The total number of vacancies, the vacancies stock at a given period  $t$ , is given by the addition of equation 3.4 and 3.5, and it can be represented as:

$$V_t = V_t^e + V_t^r \quad (3.6)$$

Employment of the firm, in a given period, is given by the level of employment in the previous period, plus contemporaneous hires, minus contemporaneous separations; the following equation represents this.

$$e_t = e_{t-1} + h_t - s_t$$

Substituting equation 3 into the previous expression, we obtain the following expression for gross employment changes:

$$\Delta e_t = (\theta_0 - 1)s_t + \sum_{\tau=1}^L \theta_\tau s_{t-\tau} + \sum_{\tau=0}^R \phi_\tau \vartheta_{t-\tau} + \epsilon_t \quad (3.7)$$

Equations 3.3 and 3.7 represent the hiring behavior of the representative firm and the movement equation of the firm's level of employment. The variables  $e_t, s_t, h_t$  are assumed to be observable factors in equations 3.6 and 3.7. The empirical literature on job and worker flows use plant-level data, which are usually samples of firms from specific economic sectors (Davis et al., 1997). In some cases, studies use information for all formal firms in a specific US state (Burgess and Stevens, 2000). In other cases, studies used linked employer-employee panel datasets for the universe of formal firms for a specific country (Morales and Medina, 2016). In all those cases  $e_t, s_t, h_t$  are observable variables; nevertheless, in those datasets vacancies are not observed. Datasets containing information on vacancies are very uncommon; one example for the US is the Job Openings and Labor Turnover Survey (JOLTS) (Davis and Haltiwanger, 2014). This is a monthly sample of approximately 16000 establishments per month, where responders report hires, separation, and job openings since December 2000.

In the next subsection, we propose a methodology that allows predicting the firm's flows and stocks of replacement and expansion vacancies, using for this purpose firms' information on separations, hires, and employment. This is useful for several reasons, many of which have been expressed before; the most relevant of these reasons is that datasets containing information on vacancies are very scarce. For many economies in the world, it is possible to study firms' hiring behavior, employment and separations by using administrative records; nevertheless, a consistent measure of vacancies is very difficult to obtain.

### **3.2 Predicting vacancies from firms' hiring behavior**

In this subsection, we propose a simple methodology for predicting the stock of replacement, expansion and total vacancies, using for this purpose firms' longitudinal information on hires, separations, and employment. Let us assume that firm's job creation follows a Poisson counting process; therefore, the flow of expansion vacancies for all firms, at a given period  $t$ , is identically and independently distributed Poisson with media and

variance  $\vartheta_t$  (i.e.,  $\vartheta_{jt} \sim \text{poisson}(\vartheta_t)$ ). As is usually the case in employer-employee linked panels, let us assume as well that the flow of hires and separations, and the employment level, are observed in the data for each firm; nevertheless, vacancies are not observed in the data. With the available data, an estimated version of equation 3 can be represented as:

$$h_{jt} = \sum_{\tau=0}^L \theta_{\tau} s_{jt-\tau} + \alpha_t + u_t \quad (3.8)$$

where  $\hat{\alpha}_t$  is a time fixed effect. The set of different intercepts  $\alpha_t$  are the expected value of hires when  $s_{jt-\tau} = 0$  for all  $\tau$ , therefore:

$$E[h_{jt} | s_{jt-\tau} = 0, \forall \tau] = \sum_{\tau=0}^R \phi_{\tau} \vartheta_{jt-\tau} \quad (3.9)$$

An estimation of this previous expectation in equation 3.8 is:

$$E[h_{jt} | s_{jt-\tau} = 0, \forall \tau] = \alpha_t \quad (3.10)$$

If in equation 3.8  $E[u_{jt} | s_{jt-\tau} = 0] = 0$ , and in equation 3.3  $E[\epsilon_{jt} | s_{jt-\tau} = 0, \vartheta_{jt-\tau}] = 0$ , it can be seen from equations 3.9 and 3.10 that in equation 3.8 intercepts  $\alpha_t$  would capture the effect of the whole polynomial that is unobserved in this equation; therefore,  $\sum_{\tau=0}^R \phi_{\tau} \vartheta_{jt-\tau} = \alpha_t$ . We assume that the flow of the expansion vacancies is such that  $\vartheta_{jt} \sim \text{poisson}(\vartheta_t)$ , therefore, the mean of these vacancies may change in time. A reasonable assumption is that the mean of this process is relatively stable in time, in other words, for a set of periods it may remain unaltered. If  $\vartheta_t$  does not change during the  $R+1$  periods of the expansion vacancies polynomial, then we can express the mean of the expansion vacancies as follows:

$$\alpha_t = E \left[ \sum_{\tau=0}^R \phi_{\tau} \vartheta_{jt-\tau} \right] = \sum_{\tau=0}^R \phi_{\tau} E[\vartheta_{jt-\tau}] = \vartheta_t \sum_{\tau=0}^R \phi_{\tau} = \vartheta_t \quad (3.11)$$

The last equality comes from the assumption that  $\sum_{\tau=0}^R \phi_{\tau} = 1$  in equation 3.2. A possible interpretation of equation 3.11 is the following: if the mean of the process that generates expansion vacancies is stable, at least during  $R+1$  periods, the time varying intercepts in

equation 3.8 are equal to the mean of the expansion vacancies in each period. Therefore, by estimating  $\hat{\alpha}_t$  we can get an estimation of the expected value of expansion vacancies, for a given period,  $\vartheta_t$ . In the first stage of the procedure, we propose in this paper, we estimate equation 3.8 and collect all  $\hat{\alpha}_t$  coefficients. In the next section of the paper, using Monte Carlo simulations, we show that  $\hat{\alpha}_t$  is a good estimator of  $\vartheta_t$ .

In the second stage of the procedure, we use all estimated parameters  $\hat{\alpha}_t$  to simulate Poisson Distributed variables  $\tilde{\vartheta}_{jt} \sim \text{poisson}(\hat{\alpha}_t)$ . These variables are realizations of the process that generates the expansion variables for each firm  $j$ . In the applied work in a further section, we test the sensitivity of the vacancies computation to using different distributional assumptions; result turns out to be very similar, regardless of the distribution used. Once we have created simulated realizations of the expansion vacancies, we estimate the following version of equation<sup>6</sup> 3.7:

$$\Delta e_{jt} = (\theta_0 - 1)s_t + \sum_{\tau=1}^L \theta_{\tau} s_{jt-\tau} + \sum_{\tau=0}^R \phi_{\tau} \tilde{\vartheta}_{jt-\tau} + \epsilon_t \quad (3.12)$$

Using bootstrap techniques, we repeat the procedure described before for an amount  $I$  of iterations; then, we compute estimators for  $\theta_{\tau}$  and  $\phi_{\tau}$  as sampling averages from the sample of bootstrap iterations. Analogously we obtain standard errors for the estimators. With our estimators  $\hat{\theta}_{\tau}$  and  $\hat{\phi}_{\tau}$ , in each iteration, we use equations 3.4 and 3.5 to compute stock of replacement vacancies  $\hat{V}_t^r$ , the stock of expansion vacancies  $\hat{V}_t^e$ , and the stock of total vacancies  $\hat{V}_t = \hat{V}_t^e + \hat{V}_t^r$ .

We use Monte Carlo simulations to assess the ability of the procedure described before to get unbiased and precise predictions of the different vacancies stock. We explain these Monte Carlo experiments in the next section.

#### 4. Monte Carlo Simulations.

We test the procedure presented in the previous section using Monte Carlo experiments. We simulate 1000 firms, in 100 time periods; all firms start in the first period with 1000

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<sup>6</sup> Since we assume in the theoretical model of hiring behavior that  $\sum_{\tau=0}^R \phi_{\tau} = 1$  (i.e. all expansion variables are filled eventually), we impose such restriction in the second stage of our applied work.

workers. In an iterative process, we generate 1000 samples of a data generator process<sup>7</sup> characterized for polynomials of length  $L=3$  and  $R=3$ . Another characteristic of the data generation process is that separations and expansion vacancies follow a Poisson distribution with mean  $\bar{s}_t$  and  $\bar{\vartheta}_t$ , respectively. To introduce some stability in the data generator process, we assume that  $\bar{s}_t$  and  $\bar{\vartheta}_t$  vary by regimes within the whole period that the firm is observed, but within each regime they remain unaltered. By a regime we mean a collection of time periods, each the same length, in which  $\bar{s}_t$  and  $\bar{\vartheta}_t$  are constant<sup>8</sup>.

Once the series of  $\bar{s}_t$  and  $\bar{\vartheta}_t$  are computed, separations and expansion vacancies are generated as follows:  $s_{jt} \sim \text{Poisson}(\bar{s}_t)$  and  $\vartheta_{jt} \sim \text{Poisson}(\bar{\vartheta}_t)$ . In appendix A we present a graph of an example of the evolution of  $\bar{s}_t$  and  $\bar{\vartheta}_t$ . In each iteration of the experiment we generate  $s_{jt}$  and  $\vartheta_{jt}$  for 1000 firms in 100 time periods. Then, using equation 3.3, we generate hires<sup>9</sup> ( $h_{jt}$ ). From the identity  $e_t = e_{t-1} + h_t - s_t$ , we generate firms' total employment in each sample<sup>10</sup>. Therefore, in each iteration of the procedure, we generate a random sample of the following set of variables  $s_{jt}, h_{jt}, e_{jt}$  for each firm  $j$  in all  $t$  periods; we use this information to develop the procedure described in section 2. We compute final estimators for  $\theta_\tau$  and  $\phi_\tau$  as sampling averages of estimators from single iterations. With estimators  $\hat{\theta}_\tau$  and  $\hat{\phi}_\tau$ , in each iteration, we use equations 3.4 and 3.5 to compute aggregated stocks and flows of expansion, replacement, and total vacancies,  $\hat{V}_t, \hat{V}_t^e, \hat{V}_t^r, \hat{v}_t, \hat{\vartheta}_{jt-\tau}, \hat{\pi}\hat{s}_t$ , respectively. Then, we compare these predictions with the real

<sup>7</sup> The real value of the parameters in equation (3) are the following:  $\phi_0 = 0.2, \phi_1 = 0.15, \phi_2 = 0.1, \phi_3 = 0.05; \theta_0 = 0.4, \theta_1 = 0.3, \theta_2 = 0.2, \theta_3 = 0.10$

<sup>8</sup> We represent each regime by  $T$ . At period one we fix  $\bar{s}_0$  and  $\bar{\vartheta}_0$ , for subsequent periods these means are determined as follows:  $\bar{s}_T = \left(\frac{1}{T}\sum_{t=0}^T \bar{s}_t\right) + \kappa_t$ ;  $\bar{\vartheta}_T = \left(\frac{1}{T}\sum_{t=1}^T \bar{\vartheta}_t\right) + \nu_t$  (3.13)

$$\text{where, } \begin{pmatrix} \kappa \\ \nu \end{pmatrix} \sim \mathbb{N} \left( \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \Sigma \right) \text{ and } \Sigma = \begin{pmatrix} \sigma_{\bar{s}_T}^2 & -1/4 \\ -1/4 & \sigma_{\bar{\vartheta}_T}^2 \end{pmatrix}.$$

Equation 3.13 determines the evolution of the means of the separation and expansion vacancies process; these means are moving averages of up to period  $t \leq T$  plus a random shock centered in zero and negatively correlated between separations and expansion vacancies.

<sup>9</sup> Measurement error is assumed to be  $\epsilon_i \sim \mathbb{N}(0, \sigma_\epsilon^2)$ , where  $\sigma_\epsilon$  is a fraction of the sampling standard deviation of hires.

<sup>10</sup> In equation 7 we introduce additional measurement error which is assumed to be  $\epsilon_i \sim \mathbb{N}(0, \sigma_\epsilon^2)$ , where  $\sigma_\epsilon$  is a fraction of the sampling standard deviation of hires.



values generated by the Monte Carlo experiments to assess the ability of the procedure proposed in section 2 to consistently and precisely predict the stock and flows.

Graph number 1, shows the predictions of vacancy flows and stocks for three different specification models, but the same data generator process. In all cases, for each iteration of the Monte Carlo experiments, data are generated using a polynomial of length  $L=3$  and  $R=3$  in the hiring function (equation 3.3). The first column in the panel of graphs represents an estimation with  $L=2$  and  $R=2$ , the second column presents the estimation with  $L=3$  and  $R=3$ , and finally, the last column presents the estimation with  $L=4$  and  $R=4$ . The first row of the graph's panel presents the predictions for the stock of total vacancies; the second and third row shows the prediction for the flow of replacement and expansion variables, respectively. In appendix B, we present estimation results for each specification.

As it can be seen from Graph 1, as long as the model is well specified (i.e., the correct amount of lags are included) the method we proposed in Section 3 does a good job of predicting the flows and stocks of replacement, expansion and total vacancies. In such a case, the real value of vacancy stock is always contained within the 95% confidence interval of the prediction. When the model is over-specified ( $L=4$ ,  $R=4$ ) the estimation still shows a good performance in predicting the flow of replacement and expansion vacancies, but this performance is poorer in the prediction of the stock of total vacancies. The same is the case when the model is under-specified ( $L=2$ ,  $R=2$ ), the prediction of the total vacancy stock is biased, and the same happens to the prediction of replacement vacancy flow. In estimations with different specification, which are not shown for the sake of ease in the presentation, we find the same conclusion; inconsistent estimation of the stock of total vacancies is obtained from over- and under- specified models.

## Graph 1: Vacancies Predictions

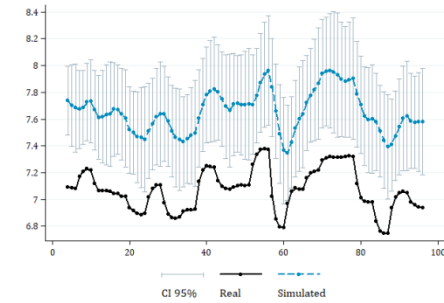
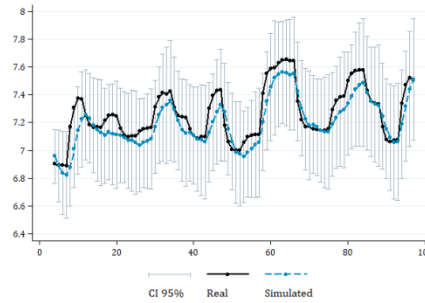
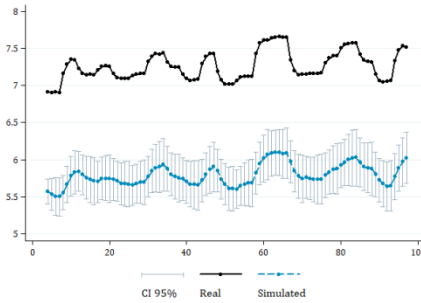
Specification

**L=2, R=2**

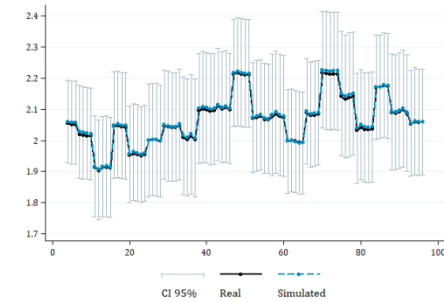
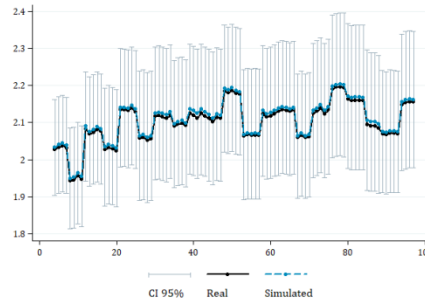
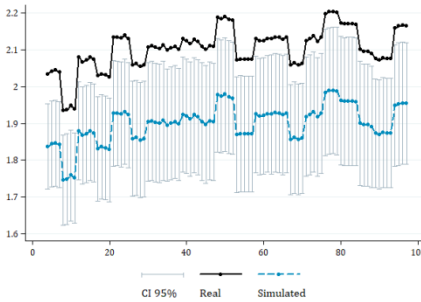
**L=3, R=3**

**L=4, R=4**

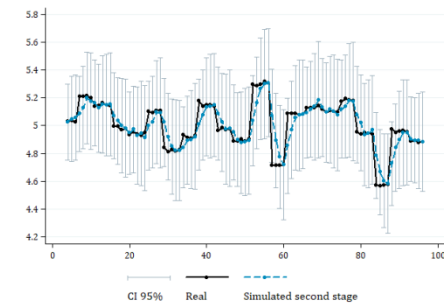
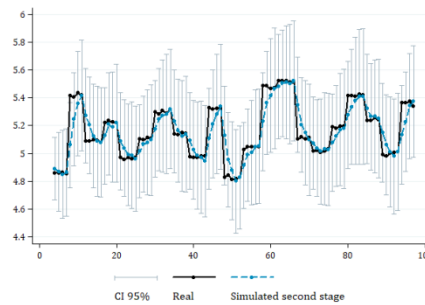
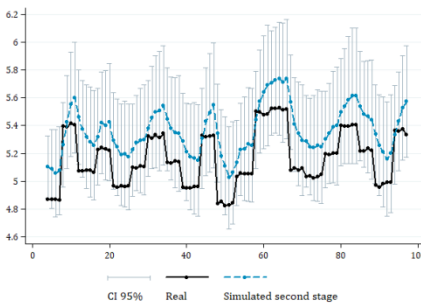
**1. Total Stock of vacancies**



**2. Flow of replacement vacancies**



**3. Flow of expansion vacancies**



Notes: Data are generated using a polynomial of length  $L=3$  and  $R=3$  in the hiring function. Since we assume in the theoretical model of hiring behavior that  $\sum_{\tau=0}^R \phi_{\tau} = 1$  (i.e. all expansion variables are filled eventually), we impose such restriction in the second stage regressions.

## 5. Vacancies Stock Estimation for Colombian Labor Market

### 5.1 Data

In this section we apply the procedure proposed in section number 3, using for this purpose a Colombian employer-employee linked panel. This panel is generated from administrative records from the “Integrated Record of Contributions to Social Security,” PILA, by its acronym in Spanish<sup>11</sup>, which is provided by the Ministry of Social Security in Colombia. PILA is a unique source of longitudinal information containing wages, employment, economic activity, and other characteristics, for the employer and the employee (Morales and Medina, 2016). Using PILA, we analyze the evolution of each firm’s payroll and construct hires, separation and employment size (on a monthly basis). These measures correspond to the employees observed in a month that were not observed in the previous one, the employees observed in the prior period not observed in the current one, and the total size of the firm in a given period, respectively (Medina et al., 2016). These previous variables, together with job creation and job destruction, are the most standard measures used in the literature on worker and job flows; job creation and destruction correspond to the absolute value of employment changes when firms experience positive or negative growth, respectively.

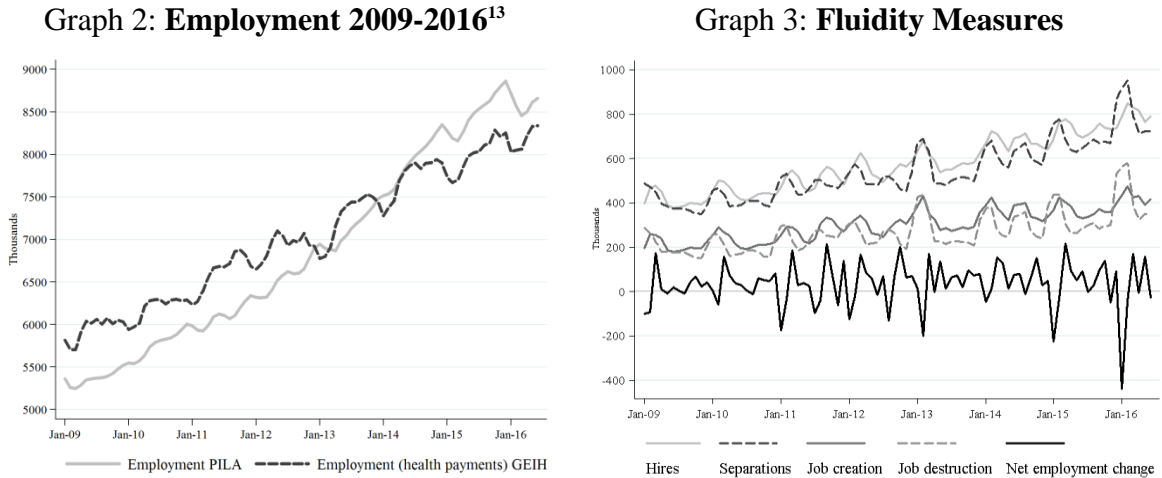
As previous studies using PILA have pointed out, one of the advantages of this data is that all worker and firm flows described in the preceding paragraph can be computed for all economic sectors (Morales and Medina 2016, Medina et al. 2016). A common practice in the literature of job and worker flows is using only plant-level manufacturing data (Davis et al., 1996, Davis and Haltiwanger, 2014). As is shown in graph 2, the PILA captures the size of the formal labor market in Colombia well; the graph compares the total formal workers from PILA and the official household survey, GEIH<sup>12</sup>. The solid line represents the employment from firms registered in PILA with more than a single employee; the dotted line represents, at the national level, the formal employees from GEIH, which are formal in

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<sup>11</sup> As explained in Morales and Medina (2016), the Ministry of Social Security in Colombia collects information from all social security-related payments from employers. This information included firms’ characteristics as wages, employment size, and some information from employees as general socio-demographic characteristics.

<sup>12</sup>by its acronym in Spanish is the official source of all of the labor market indexes in Colombia. The survey is representative of the main 23 Colombian metropolitan Areas.

the sense that they and their employers pay social security contributions. Graph 2 presents the hires, separation flows, and traditional measures of job creation and job destruction. As Graph 3 shows, the formal Colombian labor market is relatively dynamic, in 2016 there were more than 7,700,000 formal workers on a monthly basis; during the same year, on average, more than 806,974 and 803,797 monthly hires and separations, respectively, were generated (Flórez et al., 2017).



Source: PILA; Include establishments with at least two employees; authors’ calculations

**5.2 Vacancies Stock for Colombian Formal Labor Market**

We perform the technique proposed in section 3.2 for two samples; the first one is a sample containing all formal firms with more than 50 employees (average during the whole period), and the second one containing all firms with less than 50 employees and at least 5. We exclude very small firms from the sample to enhance the quality of the data<sup>14</sup>. Therefore, to obtain an estimation of the vacancy stock, we estimate versions of equation 3.8 (first stage) and equation 3.12 (second stage) for samples of big and small Colombian formal firms. To control for any kind of correlation between permanent unobserved heterogeneity and independent variables in equations 3.8 and 3.12 our results are based on fixed effect (FE) panel estimation. For the sake of comparison, we also present some of the

<sup>13</sup> The employment time series from GEIH excludes self-employed and those whom health insurance payment is not in charge of the employer, employee or both.

<sup>14</sup> We exclude from the estimation sample outliers in the top 99.5 percentile of the distribution of average firms’ size.

results obtained from an Ordinary Least Squares (OLS), a simpler regression; nevertheless, fixed effect panel regression will be our preferred specification.

An empirical matter that must be established for the estimation of equation 3.8 and equation 3.12 is the length of the polynomial lags. We start the estimation of equation 3.8 with parsimonious specifications with just one lag, and then we add more lags, one by one, until the last lag added is significant. The chosen model is the one that fulfills the criterion that all lags are significant and has the minimum root mean square error. In addition, we assume that the time in which firms fill out their replacement vacancies should be similar to the time in which they fill out their expansion vacancies. Therefore, once the optimal number lags are determined in equation 3.8, this same number of lags is used in equation 3.12 for the  $\theta$  and  $\phi$  polynomials.

In table number 1 we present the estimation results of equation (3.12); this table is arranged in two different panels, one presenting the results of estimation for big firms (OLS and FE), and one presenting the results for small firms with more than 5 and less than 50 employees (OLS and FE). The first thing to notice from Table 1 is that the best model we identified applying the criteria described before is a model with four lags. We determined the best specification using the FE model, and then we estimated the same specification by OLS.

As the reader may remember, the filling process of expansion and replacement vacancies is described by  $\phi_\tau$  and  $\theta_\tau$  coefficients, respectively. The summation of all  $\theta_\tau$  coefficients (the parameter  $\pi_\tau$  in the theoretical model) can be interpreted as the average proportion of separations that translate to replacement vacancies and eventually become hires. Comparing the coefficients obtained from OLS and FE, there are substantial differences in the magnitude of  $\theta_\tau$  coefficients. From OLS regressions, we obtain that large (small) firms replace 83% (64%) of their separations; the magnitude of these effects is lower with the FE model, in which case, estimations results indicate that large (small) firms replace 56% (34%) of their separations. These differences between OLS and FE results have an interesting implication; even though the prediction of the total vacancies stock is very similar between both estimation methods, the composition of the stock is very different. Since in FE estimation the  $\theta_\tau$  coefficients are smaller, the resulted configuration of the

vacancy stock is less determined by replacement vacancies than the predictions from OLS. We comment deeper on this issue in further paragraphs.

Estimations from our preferred specification (FE model) indicate that, regardless of the size of the firm, the filling process of expansion vacancies intensifies in the first period the position is created. Therefore the contemporaneous  $\phi$  coefficient is the largest of all. Regarding replacement variables, estimations show that the process of filling replacement vacancies is heavily concentrated in the first month after the replacement vacancy is created, as a result of a separation. In the case of small firms, a considerable proportion of 8% of all vacancies is filled out, contemporaneously with its creation. In contrast, in regard to large firms, the contemporaneous  $\theta$  coefficient is small, but negative, which may seem counterintuitive. We think this negative coefficient captures the fact that, for the case of larger firms, in periods of intense hiring, contemporaneous separations are low; therefore, contemporaneously, the FE model captures a small negative effect of separations on hiring. In OLS regression, the contemporaneous  $\theta$  coefficient is small and positive.

**Table 1: Estimation Results of Equation 3.12**

Parameter	Less than 50 employees						More than 50 employees					
	FE			OLS			FE			OLS		
	Coeff	Std. Err.	t	Coeff	Std. Err.	t	Coeff	Std. Err.	t	Coeff	Std. Err.	t
$\theta_0$	-0.92	0.003	-331.48	-0.83	0.003	-312.70	-1.04	0.011	-92.09	-0.97	0.012	-81.45
$\theta_1$	0.21	0.003	62.92	0.28	0.003	88.74	0.42	0.111	3.81	0.49	0.097	5.06
$\theta_2$	0.05	0.002	21.16	0.11	0.002	47.08	0.14	0.017	8.18	0.21	0.022	9.45
$\theta_3$	0.00	0.002	1.90	0.08	0.002	33.05	0.03	0.014	2.14	0.10	0.022	4.73
$\phi_0$	0.28	0.001	243.45	0.29	0.002	182.80	0.47	0.036	13.22	0.58	0.040	14.37
$\phi_1$	0.25	0.001	227.49	0.25	0.001	168.11	0.19	0.019	9.96	0.16	0.023	6.96
$\phi_2$	0.24	0.001	219.61	0.23	0.001	154.65	0.15	0.027	5.60	0.08	0.029	2.72
$\phi_3$	0.24	0.001	212.68	0.24	0.002	153.40	0.19	0.016	11.76	0.19	0.022	8.36
$\pi$	0.34			0.64			0.56			0.83		

**Notes:** Robust standard errors are computed and clustered by firm. The coefficient that multiplies, contemporaneous separations is  $(\theta_0 - 1)$  as denoted in equation 3.12. The  $\pi$  parameter is obtained as  $\sum_{\tau=1}^T \theta_{\tau}$ . As expressed in equation 3.12, the regression does not include an intercept; nevertheless, results do not change importantly in regressions including an intercept. In these regressions we impose the restriction  $\sum_{\tau=0}^R \phi_{\tau} = 1$ , as it is assumed in the theoretical model.

In graphs 4 and 5, we present the total stock of formal vacancies in Colombian labor market, which were obtained with the FE coefficients and the OLS coefficients, respectively. The stock of expansion, replacement, and total vacancies is constructed using

the formulas 3.4, 3.5, and 3.6, respectively. When firms are born during the period of study, there is a flow and a stock of vacancies, previous to the very existence of the firm, which we have to take into account. In this case, we need a correction to recover the vacancies that generated the hires from the first period that newborn firms are observed. When a firm is born, there is an amount of vacancies equivalent to  $h_{j,0} - \phi_0 \tilde{\vartheta}_{j,0}$ , which are the hires in the first period that filled out previously created positions. These additional vacancies correspond to flows and stocks from a firm's pre-existing period. Since our models reveal that firms take up to three months to fill out their vacancies, we assume that the flow of creation vacancies during the previous three months the firm is born is just  $\frac{1}{3}(h_{j,0} - \phi_0 \tilde{\vartheta}_{j,0})$ . For newborn firms, the stock of expansion vacancies during this pre-existing period is just the summation of these pre-existing flows. We assume all the vacancies in the pre-existing period are filled out in the period the firm is born<sup>15</sup>. In Appendix C, we present a graph of the stock of vacancies with and without the correction.

In Graphs 4 and 5, we aggregate stock vacancies for small and big firms. As commented before, the average vacancy stock estimated for FE and OLS specifications are similar, 665k for the FE estimation and 683k for the OLS estimation, on average for the study period. Nevertheless, the composition of this total stock is entirely different; predictions from OLS models overestimate the stock of replacement vacancies and underestimate the stock of expansion vacancies. From our preferred specification, the FE model, we estimate that 53% of all vacancies correspond to expansion and the remaining 47% correspond to replacement vacancies. From the OLS estimation, we predict a replacement vacancy stock that is more than 74% of the total stock. From now on, we will only comment the results from the FE model.

The total stock of vacancies for a given period, 665k on average for the study period, may seem high for a medium size economy as the Colombian economy; our estimated vacancies are higher than other vacancy measures computed from administrative records; we

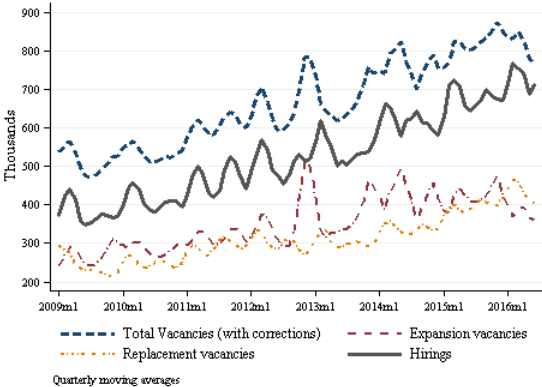
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<sup>15</sup> There are different alternatives to develop a correction for newborn firms; one can assume that the behavior of expansion vacancies is equivalent before and after the origin of the firm. In one of our attempts to develop a correction, we use the equation for the first period hires of the firm (i.e.  $h_0 = \sum_{\tau=0}^R \phi_{\tau} \vartheta_{t-\tau} + \epsilon_t$ ) and from there we solve close forms for the pre-existence expansion vacancies. We decided to turn down such a correction because the negative flow of vacancies may result, which is counterintuitive and difficult to interpret.

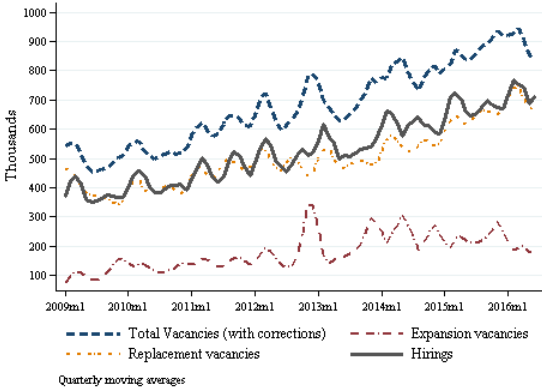
comment on this in a forthcoming paragraph. Nevertheless, the average monthly hiring for firms greater than 5 employees during this period, which is represented in Graph 2, was nearly 530k hires per month, this amount of hires must be generated by a considerable stock of vacancies. Theoretically speaking, the stock of vacancies must be greater than the flow of hires in a given month; this is because there are frictions in labor market and the hiring that requires filling all expansion and replacement vacancies does not occur contemporaneously.

As our estimation of equation 3.12 shows, it takes three months for the average small and large firm to fill out all their vacancies. Graph 2, presented before, shows hires, separations, and employment change from PILA; the magnitude of workers movement is important, therefore, an aggressive and dynamic stock of vacancies must support the magnitudes of these flows. The official record<sup>16</sup> of vacancy stock, reported by the government agency in charge of gathering information on all vacancies, says that the stock of vacancies in Colombia was 309k, on average for the year 2016; this amount of vacancies is substantially little, considering the magnitude of the worker flows observed in PILA. Finally, it is worth mentioning that there is a notable increase in the stock of vacancies in the last semester of 2013. A reform in the tax code was implemented that year that strikingly reduces labor costs, it has been shown in several papers that the reform created a considerable amount of jobs (Morales and Medina, 2017; Fernandez and Villar, 2016).

Graph 4: Vacancy Stocks Fixed Effects



Graph 5: Vacancy Stocks OLS



<sup>16</sup> These records were constructed from quarterly or monthly bulletins available in the *Servicio Público de Empleo* website. “Servicio Público de Empleo” is a relatively new government agency in charge of collecting information on all vacancies in Colombia.



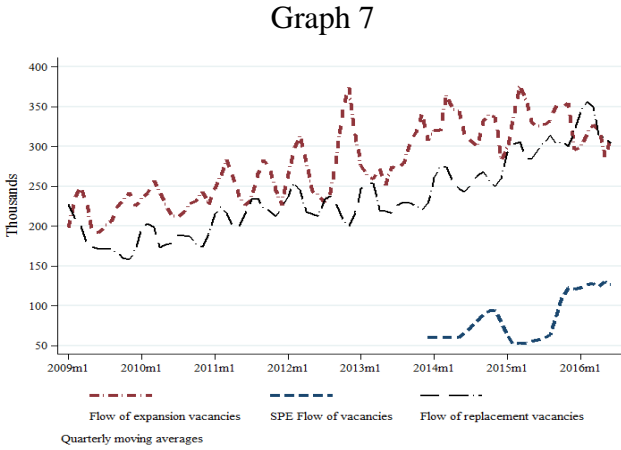
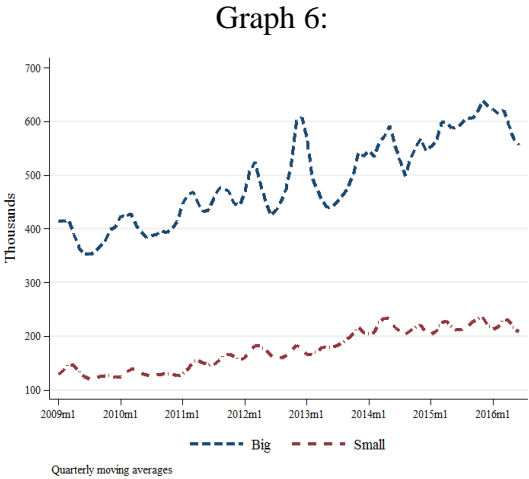
Notes: The stock for expansion, replacement, and total vacancies is constructed using the formulas 3.4, 3.5, and 3.6, respectively, and the coefficients reported in table 5.1. The vacancies and hires presented in this graph correspond to firms with at list 5 employees; also, outliers in the top 99.5% of the distribution of average size are excluded from the analysis.

Graph 6 presents the vacancies stock for small and big firms; as can be seen from this graph, most of the vacancy stock (nearly 74%) comes from firms with more than 50 employees. Nevertheless, the proportion of expansion vacancies over total vacancies is greater for small firms than for big firms; the percentage of expansion vacancies is 79% in the case of the former and 44% in the case of the latter. Regarding the whole sample, as we mentioned before, the proportion of expansion to total vacancies is 53%. In the literature on labor market flows, it has been reported that relative to its size, small-medium firms tend to create more jobs than their larger counterparts. In a recent paper, Flórez et al. (2017) conclude that average net employment growth rate is substantially higher for formal firms with less than 50 employees in Colombia. There is plenty of international literature reporting similar patterns for other countries (Birch, 1981; Baldwin and Picot, 1995; Broersma and Gautier, 1997; Anyadike-Danes et al., 2011).

Graph 7 presents the flow of replacement and expansion vacancies estimated from the procedure proposed in section 3.2. The flow of replacement vacancies is computed as the proportion of separations produced in particular period that eventually will be replaced (i.e.  $\pi_{s_t}$ ). The flow of expansion vacancies is computed as the aggregation of simulated variable  $\tilde{\vartheta}_{jt}$ , as is explained in section 3.2. Graph 7 also presents the flow of SPE vacancies, which comes from the governmental agency in charge of collecting information on vacancies in Colombia (Servicio Público de Empleo). This governmental agency has an online platform where all firms are required to post any vacancy they have open. Our estimations reveal that on a monthly basis the formal labor market in Colombia, on average for the study period, produces a continuous flow of 531K vacancies. This flow of 531K monthly vacancies creates 570k hires per month, on average, registered for the Colombian formal labor market during 2009 and 2016 (see Graph 3). The number of vacancies registered by the SPE in Colombia is extremely low (an average of 84k for 2014-2016), and it does not reflect the magnitude of monthly hires recorded by PILA.

Finally, we comment on the similarity of our vacancies prediction with the results from a different methodology. In Appendix E, we present a comparison between the vacancy index

computed from our methodology and an adjusted “help wanted” index, which is calculated using the method proposed in Arango (2013). Surprisingly enough, both series behave relatively similar, and they share a very similar trend; the correlation between both series is 84%.



**Notes:** The vacancies and hires presented in this graph correspond to firms with at least 5 employees; also outliers in the top 99.5% of the distribution of average size are excluded from the analysis. The flow of expansion variables correspond to  $\tilde{\vartheta}_{jt}$  and the flow of replacement vacancies correspond to  $\pi_{st}$ , as is explained in section 3.1 and 3.2. The flow of vacancies from “Servicio Público de Empleo” (SPE) comes from the governmental agency in charge of collecting information on vacancies in Colombia. Reports from SPE are available at [www.serviciodeempleo.gov.co](http://www.serviciodeempleo.gov.co).

**6. Using Estimated Vacancies to Measure Job Creation, Job Destruction, and Worker Replacement**

In sections two and three, we conclude that expansion vacancies are the core of the job creation process. Replacement vacancies are filled by workers that will occupy a position that another worker had before; in contrast, expansion vacancies represent only new positions. Therefore, expansion vacancies constitute the real engine of job creation. In the literature on worker and job flows, a very standard measure of Job Creation (Job Destruction) is the employment net growth rate, when this growth is positive (negative). Literature expressed Job Creation and Destruction rates as proportions of an employment measure size, which is, the second order moving average of employment. From this paper’s narrative, these traditional job flow measures could be considered at least imprecise. In the case of Job creation, for instance, some of the hires that explain total employment positive growth may be the fulfillment of replacement vacancies that were generated several months

before. In the case of the job destruction, a firm might have destroyed job positions in periods of positive net growth. This may happen because employment change is also determined by hires driven by worker replacements or previous expansion vacancies.

Estimating vacancy flows and stocks allow us to have a deeper understanding of the concepts of job creation and destruction. It is well known that these traditional measures are just proxies of real processes of job creation and destruction. As commented before, all job destruction is not necessarily reflected in firms' employment growth; in the same way, the magnitude of job creation is not necessarily precisely reflected in firms' employment growth. With estimates of expansion and replacement vacancies stock and flows, we can distinguish creation -or destruction- of new positions and employment growth as two different phenomena.

Taking advantage of our methodology's outcomes, we propose as an alternative measure of job creation, the ratio expansion vacancies flow over total employment size<sup>17</sup>; we will refer to this measure as Job Positions Creation (JPC). We argue that our measure is better than the traditional measure because only expansion vacancies should be associated with the creation of new job positions. In our framework, destruction of job positions is the complement of replacement vacancies because, from the establishment point of view, the positions that are not eventually replaced are lost forever. As an alternative measure of job destruction, we propose the ratio: total separations minus the flow of replacement vacancies over employment size; we will refer to this measure as Job Position Destruction (JPD). Since the separations that are never replaced are equivalent to the destroyed job positions, we can identify destruction of previously existing job positions independently from employment reductions.

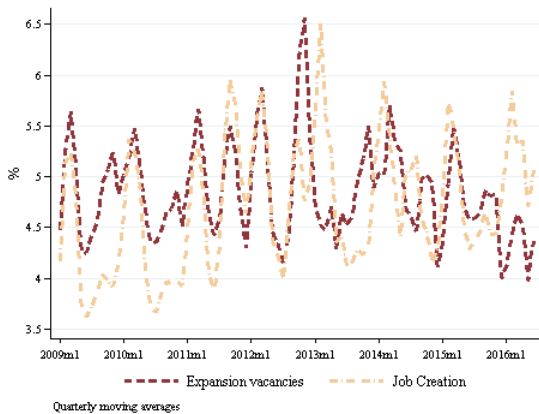
In graph 8 we show the creation of new job positions (JPC), expressed as the flow of expansion vacancies as a proportion of firm size, which is 4.9% on average for the study period. The magnitude of the traditional job creation rate is 4.7% on average for the study period. Job Creation rate is smaller than our measure of Job Positions Creation, but they are not remarkably different. There is not a rule determining if JPC should be smaller or greater

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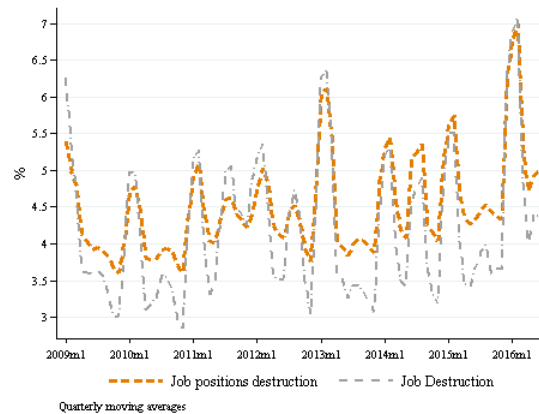
<sup>17</sup> Employment size is computed as a second order moving average of the total number of workers, which is a standard practice in the literature (Davis et al., 1996).

than traditional job creation; the direction of the Job Creation bias will depend on the flow of separations and hiring due to previous vacancies<sup>18</sup>. Nevertheless, this similarity reflects the fact that, positive changes in employment approach relatively well what our model predicts as new positions. The Job Positions Destruction (see Graph 9), which is total separations minus the flow of replacement vacancies, expressed as a percentage of employment size, is 4.5% on average for the study period. The magnitude of the job positions destruction process is higher than the magnitude of job destruction suggested by the job destruction rate, which is 4.1% on average for the study period. This means that negative changes in employment underestimate what our model identifies as separations that are not replaced again. Nevertheless, as in the case of Job Creation, theoretically, the direction of the Job Destruction bias is not unambiguous<sup>19</sup>. The job creation rate is relatively similar to our measure of job positions creation, but there is a more noticeable gap between the job destruction rate and our measure of job positions destruction. Therefore, the traditional measure of worker replacement (the churning rate), must be greater than the worker replacement that our model suggests. In the next paragraphs, we provide evidence that this is the case.

Graph 8: Expansion Vacancies/Employment



Graph 9: No Replaced Sep./Employment



**Notes:** Expansion vacancies, stands for the aggregated flow of expansion vacancies as a proportion of employment size,  $\hat{\vartheta}_{jt}$ , in equation 3.12. Job position destruction represents the difference between total separations in the flow of

<sup>18</sup> From equation (3.3) it can be seen that the traditional job creation rate will overestimate the creation of new job positions if the flow of previous expansion vacancies plus the number of previous and current replacement vacancies, filled out in the current period are smaller than contemporaneous total separations. (i.e. if  $h_t - s_t > 0 \rightarrow h_t - s_t > 0 \leftrightarrow \sum_{\tau=1}^R \phi_{\tau} \vartheta_{t-\tau} + \sum_{\tau=0}^L \theta_{\tau} s_{t-\tau} > s_t$ ).

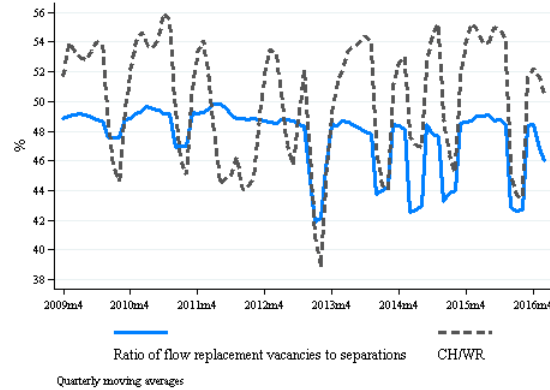
<sup>19</sup> From equation (3.3) it can be seen that the traditional job destruction rate will sub-estimate the destruction of previously existing job positions if the flow of current separation that will be created, from the current period on, is smaller than contemporaneous hires (i.e. if  $h_t - s_t < 0 \rightarrow |h_t - s_t| < 0 \leftrightarrow h_t > \pi s_t$ ).

replacement vacancies  $(1 - \pi)s_t$  in equation 3.1. Job creation and destruction corresponds to traditional measures in the literature  $1_{\{\Delta e_{it} > 0\}}\Delta e_{it}$  and  $1_{\{\Delta e_{it} < 0\}}\Delta e_{it}$ , respectively, where  $e_{it}$  stands for employment levels (see sections 3.1 and 3.2). All measures are expressed as a proportion of the employment order 2 moving average,  $\frac{1}{2}(e_{it} - e_{i,t-1})$ .

Another standard labor fluidity indicator in the literature is the churning rate; churning accounts for the excess of worker reallocation to accommodate job reallocation. Churning flows are usually computed as: (hires-job creation) + (separation-job destruction). At the establishment level, churning is often referred as "worker churning," and it is the result of the reevaluation by parties, employer, and employee, of the job-worker match (Burgess et al., 2000). In other words, churning measures the number of workers entering and exiting given job positions. Therefore, churning flows could be roughly interpreted as a measure of worker replacement. As we argue before, the problem is that the standard churning is a static measure, which does not take into account that hires, at the establishment level, are the fulfillment of vacancies that were generated several months before.

One of the advantages of our approach is that we can model the process of worker replacement, with more precision. The idea behind the churning flows is that there is a constant flow of workers quitting and being replaced, and at the same time, a flow of simultaneous hiring and firing by employers to improve the quality of their workforce (Burgess et al., 2000). Therefore, churning flows implicitly capture worker replacements for fixed positions. In order to capture this idea, we construct the ratio of the flow of replacement vacancies to separations; this is the proportion of all separations that were eventually replaced, we refer to this rate as Worker Replacement Rate (WPR). In Graph 10, we show this ratio together with the ratio of churning to worker reallocation rate. The latter represents the percentage of worker flows that corresponds to churning. As Graph 10 shows, the churning as a proportion of all worker reallocation is, on average, 50%; this is a bigger percentage in comparison with our estimations of worker replacement rate, which was 47% on average for the study period.

Graph 10: Eventually Replaced Separations/Separations



Notes: The first series represent the ratio flow of replacement vacancies to total vacancies, which is  $\pi s_t/s_t$  in equation 3.1. The second series is the ratio Churning Rate to Worker Reallocation Rate.

There are differences between our proposed measures and traditional job flow and churning rates; nevertheless, especially in the case of Job Creation, these differences are not strikingly notorious. This is a bit surprising, since traditional job flows are static and do not take into consideration that hires in a period may be the result of open vacancies several months earlier. These similarities are explained in part by the fact that our model assumes that hiring is a smooth process, which makes conditions required to reduce the standard job flow bias more plausible<sup>20</sup>.

### 6.1 Analyzing the Establishment-Level Behavior of Vacancies, Hiring, and Separations.

Using our estimation of vacancies stocks and flows, we document the relationship between vacancies, hires, and separations. In particular, we compute vacancy rates and vacancy yields. It is important to clarify that all our measures are restricted to the urban formal labor market. In Colombia, like many other developing countries, informality is rampant, but the formal labor market is still considerable. For the 23 largest cities in Colombia, in 2016, the formal labor market was nearly 51% of the whole market (Morales and Medina, 2016).

The Vacancy Rate (VR), at period  $t$ , is defined as the ratio  $\sum_j V_{jt} / \sum_j (V_{jt} + O_{jt})$ , which represents the vacancies ( $V_{jt}$ ) as a percentage of total jobs. The total amount of jobs is the

<sup>20</sup> See footnote 18, 19.

summation of vacancies and the total employed population, for the main 23 Colombian Metropolitan Areas. The working population is taken from Colombian official labor market statistics. An important caveat of our vacancy rate estimation is that we can measure only vacancies produced in the formal labor market. Our computation can be interpreted as a formal vacancy rate; nevertheless, the informal labor market is usually composed by tiny firms and self-employed individuals, in these cases vacancies are extremely low or zero as in the case of the self-employed. The vacancy yield (VY), at period  $t$ , is defined as the ratio  $\sum_j h_{jt} / \sum_j V_{jt-1}$ , which represents hires as a percentage of the stock of vacancies at the end of the previous month. These two measures, or derivations of them, have been extensively used in the literature on vacancies (Davis et al., 2013). We analyze the dynamics of these measures in reference to traditional worker-and-job flow measures, and unemployment rates in Graphs 11 and 12.

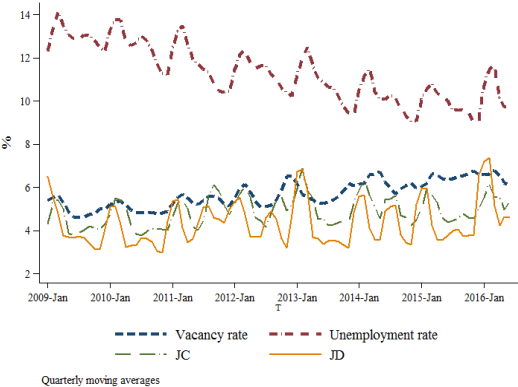
As presented in Graph 11, during this paper's study period, formal vacancy went up from nearly 5.5% in the first quarter of 2009 to nearly 7% the last quarter of 2015. The first semester of 2016 is characterized by an important reduction in the vacancy rate, which coincides with an increase in the urban unemployment rate. The sizeable increase in the vacancy rate previous to 2016 takes place in a period where we observe a steady and vigorous growth of formal employment; as shown in Graph 2, during this period more than 2.5 million formal jobs were created. The vacancy yield rate we obtain has a mean of 80% during the study period; hires as a proportion of previous vacancies reached a maximum of 96% by the end of the 2016 first semester. The estimated vacancy yield is always less than one; a situation in which, consistently, aggregated hires are greater than the total vacancy stock, would be difficult to interpret. In studies using a measure of vacancies that is collected directly from establishment surveys, is not unusual to find vacancies yield rates that are greater than one in all periods.

In Graph 11, we present our estimation of vacancy rate in comparison to traditional job creation and job destruction rates, as well as the official Colombian unemployment rate. Graph 11 clearly shows that the vacancy rate increases rapidly in a period of intense reduction of the level of unemployment (from 2010 to the end of 2015). The decrease in the unemployment rate, during the majority of the study period, coincides with the observation

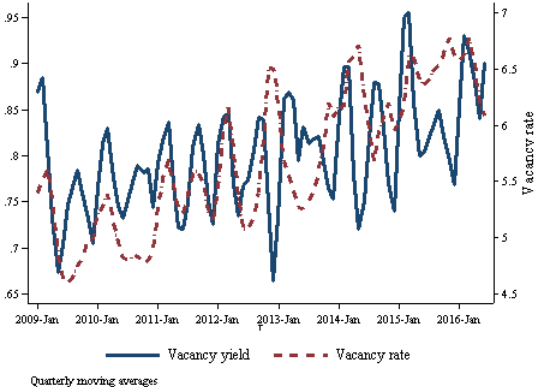
of successive months with net job creation; this can be seen from the fact that the job creation line is recurrently above the job destruction line in most of the months. All this evidence is well-suited with a vacancy rate which, importantly, increases from 2009 to the last quarter of 2015. The decreasing trend of the Colombian unemployment rate stops in the second semester of 2015. Unemployment starts growing very clearly from the beginning of 2016, which is compatible with the reduction in the vacancy rate observed in this year.

Traditional models of search predict hires will be a proportion of vacancies (Pissarsides, 2000); therefore, one would expect this measure to be smaller than one (see Graph 12). A positive relationship between vacancies and hiring has been previously documented in the literature. Davis et al. (2013) use a survey of firms that report open positions they have, and that are available to be filled during the next 30 days. Vacancies collected directly from firms are very useful; nevertheless, vacancy related variables, obtained from surveys, may be the subject of serious measurement problems. For instance, the vacancy yield reported in Davis et al. (2013) is substantially greater than one. In reference to this apparent inconsistency, authors expressed in the paper: (we) "cannot confidently infer the economic relationship between vacancies and hires from raw JOLTS data." We interpret this kind of issues associated with the measurement of vacancies as justification for the methodology we propose and use in this paper. We offer evidence in this paper that researchers can estimate a relationship between vacancies-hiring that seems more consistent with theory than the one that can be inferred using raw data on vacancies collected directly from employers.

Graph 11



Graph 12





## 7. Labor Market Tightness

In this final section, we use our vacancy stock estimation to construct measures of the tightness of the labor market. Studying the tightness of the labor market is useful for the understanding of the market's behavior throughout the economic cycle. In favorable economic contexts vacancies will thrive and unemployment will decrease, the opposite will occur in economy depressions or crisis. Therefore, vacancies and unemployment are a duplet that can effectively characterize the tightness of the labor market. The suggested measure of labor market tightness from the most standard economic search models is the ratio available of jobs to job-seekers; the higher this ratio is, the tighter the market is from the firm's point of view. A tight market means that there is a large number of available positions in relation to the job seekers who are willing to fill them; in circumstances like these, the hiring process required to fill vacancies is more challenging for firms. A frequently used tightness measure is the ratio of total vacancies to unemployed individuals (measured in thousands). We present this measure in Graph 13. Our market tightness measure shows that when the economy is near or above its potential product, market tightness increases substantially. During the last year of the study period (second semester 2015-first semester 2016), the product gap started to decrease; this coincides with the stabilization of market tightness, which for the period 2011-2015 had been increasing substantially.

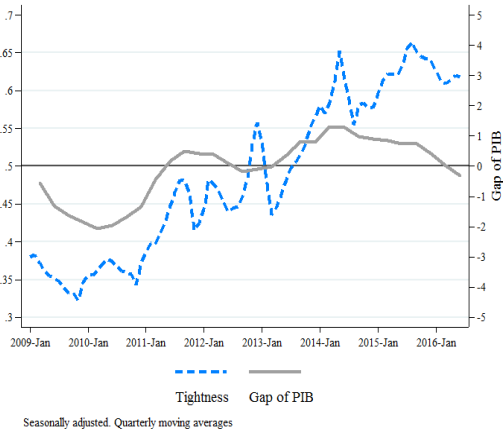
We can take advantage of our estimated vacancy stock to study the cross-section relationship between vacancy and unemployment rates; this relationship is widely known as the Beveridge curve. This relationship has its roots in search equilibrium models that predict a negative relationship between vacancy rates and unemployment rates; this prediction comes from the expression that determines the equilibrium unemployment rate in such models.

In graph 14 we show a Beveridge curve based on official urban unemployment and our estimated vacancy rate. In Graph 14, we present a locally weighted regression of vacancy rate on the unemployment rate, which allows picturing the line that better fits the set of all vacancies-unemployment duplets. The relationship presented in Graph 13 is in line with the theoretical predictions; there is a robust and nonlinear negative relationship between the

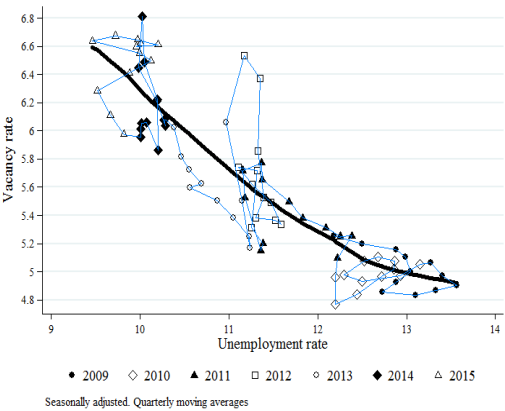
vacancy rate and the unemployment rate. As predicted by the theory, in years like 2009 and 2010 were the Colombian GDP was below the potential GDP, the labor market was characterized by the existence of low vacancy rates and a large unemployment rate. During the subsequent years, from 2011 to 2014, Colombia had a remarkable economic performance with an annual GDP growth rate of almost 5%; during this second period, one can notice how the labor market was moving left through the same Beveridge curve to higher vacancy rates and lower unemployment rates. Both Graphs 12 and 13 show that from 2011 to 2014 tightness of the Colombian market increases substantially. During the years 2015 and 2016, the Colombian economy has decelerated in comparison with previous years, at the same time unemployment has grown subtly. After the last quarter of 2015 the vacancy rate shows an important reduction.

There have been previous attempts to estimate a Beveridge curve for the Colombian urban labor market. Using information from Help Wanted advertisements collected in Arango (2013), Alvarez and Hofstetter (2014) estimate a Beveridge curve with properties similar to what is shown in Graph 14, but with substantially lower vacancy rates. For the period 1976-2012, Alvarez and Hofstetter (2014) present an average vacancy rate of nearly 2%. Since Help-Wanted advertisements methodologies cannot recover the actual level of real vacancies, they cannot identify the level of vacancy rate either.

Graph 13:



Graph 14



**Notes:** In the Beveridge curve we do not include the year 2016 because we do not have information for the second semester of this year.

## 8. A comment on Robustness

As already mentioned, all results presented in section 5, 6 and 7 are based on the implementation of the methodology proposed in section 3.2. In this method we assume that the expansion variables are distributed Poisson (i.e.,  $\tilde{v}_{jt} \sim \text{poisson}(\hat{\alpha}_t)$ ); where  $\hat{\alpha}_t$  are the intercepts estimated in the first stage of the procedure. In Appendix E, we present the stock of total vacancies, computed with the entire sample, using additional discrete and continuous distributions as an alternative to the Poisson. In all cases, these alternative distributions have positive real number or integers as support, which is the space in which simulated vacancies would make sense. In the graph we compute total stock of vacancies with negative binomial distribution, chi-squared distribution, and inverse Gaussian distribution<sup>21</sup>; all of them, in addition to the Poisson distribution, suggested by the methodology proposed in section 3.2. The estimation of the total vacancy stock is very similar, regardless of which distribution is used. Furthermore, even though the levels of the predictions may present with minimal differences, the behavior of the series is virtually the same. We explore additional distributions, which are not presented in the Graph with similar results (Gamma and Normal). In light of this evidence, we assume that the arbitrary use of Poisson distribution does not have important implications in the computation of vacancies.

## 9. Conclusions and Discussion

The concept of vacancies plays a crucial role in theoretical models of labor markets, especially in equilibrium search models, where the vacancy rate is one of the attributes of matching functions. In this paper, we have shown how vacancies are crucial in the process of worker-and-job flows formation; they are the unique source of hires, which, with separations, simultaneously explain the changes in firms' employment level. Nevertheless, in the literature on labor market flows and dynamics, the study of the link between vacancies and traditional worker and job flows measure is surprisingly scarce, only a few empirical studies analyze vacancies and its relation with hires and separations at the

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<sup>21</sup> In the case of the Inverse Gaussian distribution, we use the standard error of the  $\hat{\alpha}_t$  parameters to compute the standard deviation using a finite sample correction; then we use  $\hat{\alpha}_t$  and its standard deviation to compute the mean and shape parameter of the distribution.

establishment level, (Davis et al., 2013). One of the reasons for this gap in the literature is the difficulty of making a valid inference of the number of vacancies in the economy.

There are very limited data sources containing worker/job flows and vacancies at the same time, there are surveys like JOLTS for the US, but they are available for only a few developed countries and contain information only for some limited economic sectors. An additional caveat is that, when survey information on vacancies is available, there are measurement issues and aggregation issues that make it difficult to infer, robustly, an economic relationship between vacancies and hires (Davis et al., 2013). In the cases where data sources on vacancies are not available, researchers have used job ads in newspapers as a proxy; nevertheless, recently, with the popularization of the internet, posting ads in written newspapers is a less frequent practice.

The main contribution of this paper is proposing a methodology that allows the researcher to recover an estimate of vacancies; for this purpose, only standard information on hires, separations, and employment at the establishment level is required. The methodology we propose is based on the estimation of a hiring function, a function that is expressed in terms of replacement vacancies and expansion vacancies. This distinction between two types of vacancies reflects the fact that there are vacancies that firms open with the purpose of replacing workers that are gone, and there are vacancies that firms open for expansionary purposes. The distinction between expansion and replacement vacancies has been mentioned previously in the literature (Lazear & Spletzer, 2012), but it has not been explored in depth. The hiring function characterizes the hiring of the firm, and it is affected by rigidities of the labor market; therefore, in general, firms cannot get their desirable size instantaneously. From the estimation of the hiring function, we get the parameters we use in the prediction of flows and stocks of replacement, expansion, and total vacancies. Monte Carlo experiments provide evidence that estimations of vacancies stock are consistent, as long the specification for the hiring function is dynamically complete.

Our estimated vacancies stock and flows are reasonably sized; they are compatible with the magnitudes of the worker movements observed in Colombian formal labor market for the period 2009-2016. Analyzing the relationship of estimated vacancies with observed hires and separation flows, we reach several conclusions that enhance our understanding of

formal labor markets, and specifically the Colombian labor market. Next, we summarize some of our most important findings. Expansion vacancies are nearly 53% of total vacancies; the most important component of the total vacancy stock comes from firms' expansions or creation, which is not surprising for a period of strong employment growth. Big firms, with more than 50 employees, create 74% of total vacancies. Nevertheless, the proportion of expansion vacancies over total vacancies is greater for small firms than for big firms; the percentage of expansion vacancies is 79% in the case of small firms, and 44% in regard to large firms.

Our methodology allows computing alternative job flow measures, which we argue, can distinguish the creation (destruction) of new positions and positive (negative) employment growth as two different phenomena. We propose as well a measure of worker replacement which is similar in spirit to the ratio churning/worker-reallocation. There are differences between our proposed measures and traditional job flow and churning rates; nevertheless, especially in the case of Job Creation, these differences are not strikingly noticeable. These similarities may be explained in part by the fact that our model assumes that hiring is a smooth process, which makes the conditions required to reduce the standard job creation bias more plausible. The magnitude of the job positions destruction measure is noticeably higher than the job destruction rate; this means that negative changes in employment underestimates what our model identifies as separations that are not replaced again. The destruction measures have some differences, but creation measures are more similar; therefore, the traditional measure of worker replacement, the churning rate, is greater than the worker replacement that our model suggests.

Indirect tests for the validity of our estimated vacancies are encouraging. For instance, we obtain a vacancy yield that exhibits a stable behavior, which is in line with the economic intuition from search models. For the average firm, the ratio is always smaller than one. This is not a standard finding; previous studies have estimated this ratio to be substantially higher than one. As it is explained in Davis et al. (2013), vacancies collected directly from firms can be the subject to measurement and aggregation problems; therefore, even when researchers use firms' surveys collecting vacancies, inference of economic relationships between vacancies and other variables may not be robustly achieved. In addition, our

estimated vacancies exhibit consistent behavior in relation with variables measuring the business cycle. Vacancy rates show a pro-cyclical behavior, which is in conformity with a downward sloped estimated Beveridge curve.

To the best of our knowledge, a method of estimating vacancies from hiring behavior has not been documented previously in the literature. In general, this paper shows a somewhat unique perspective on hiring: at the establishment level, the determination of hires should be considered a dynamic process, which is directly linked to expansion vacancies and worker replacements. The method we propose may be useful in developing economies, where there are no good official sources of information on open job positions. Applications or enhancements of the methodology proposed in this paper may contribute to the analysis of vacancies and its relationship with different labor market indexes, especially in economies where data availability may be a limitation. Finally, the monthly series of vacancies stock computed in this paper are publicly available at the following website: <https://sites.google.com/site/leonardomoraleszurita/home/researchlm>.

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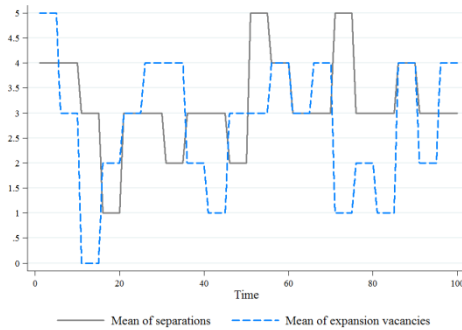
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## Appendix

### Appendix A:

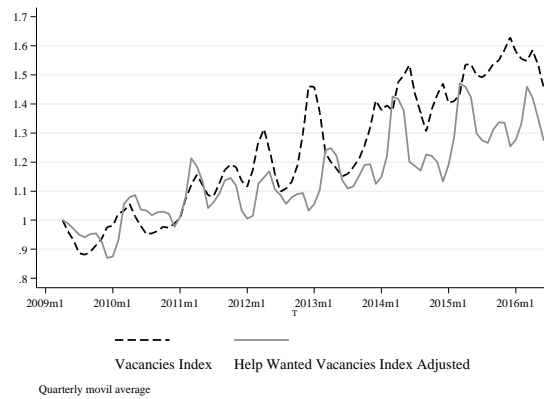
Graph of the DGP for  $\bar{s}_t$  and  $\bar{\theta}_t$  in the Monte Carlo simulations



Notes: This DGP uses 23 different regimes throughout all 100 periods of firm information.

### Appendix E:

Vacancy Index from hiring behavior vs. Help Wanted Vacancy Index



Notes: Both indexes have January of 2009 as their base. The Help wanted vacancy index is an actualization of the results in Arango (2013) kindly provided by the author.



## Appendix B: Monte Results.

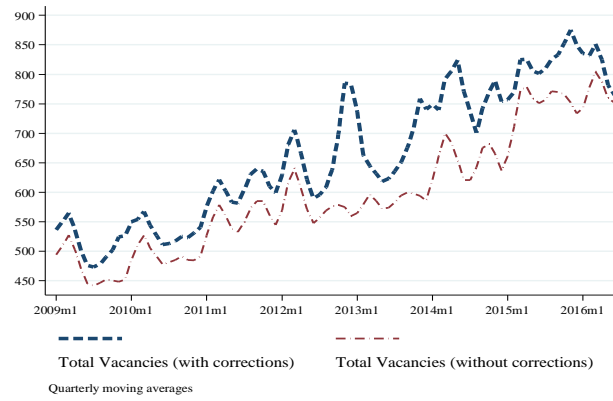
### Monte Carlo Simulations.

Series and coefficients		Number of lags			
		1	2	3	4
Mean Stock of vacancies	Real	6.99	7.25	7.25	7.07
	Estimation	3.19	5.77	7.20	7.66
	RMSE	4.27	1.94	1.35	1.57
Mean Flow of replacement vacancies	Real	2.02	2.10	2.10	2.06
	Estimation	1.41	1.89	2.11	2.07
	RMSE	0.72	0.25	0.10	0.11
Mean Flow of expansion vacancies	Real	4.98	5.16	5.16	5.01
	Estimation	5.58	5.36	5.15	5.00
	RMSE	1.32	1.18	1.16	1.12
Phi Estimation Set	Phi0 = 0.40	0.53	0.43	0.41	0.40
		0.00	0.00	0.00	0.00
	Phi1 = 0.30	0.47	0.32	0.29	0.28
		0.00	0.00	0.00	0.00
	Phi2 = 0.20		0.24	0.18	0.17
			0.00	0.00	0.00
	Phi3 = 0.10			0.12	0.09
				0.00	0.00
	Phi4 = 0.00				0.07
					0.00
Theta Estimation Set	Theta0 = 0.20	0.20	0.20	0.20	0.20
		0.00	0.00	0.00	0.00
	Theta1 = 0.15	0.15	0.15	0.15	0.15
		0.00	0.00	0.00	0.00
	Theta2 = 0.10		0.10	0.10	0.10
			0.00	0.00	0.00
	Theta3 = 0.05			0.05	0.05
				0.00	0.00
Theta4 = 0.00				0.00	
				0.00	

**Notes:** The number of regimes is 22. The standard errors are in parenthesis. The same number of lags is applied to the phi and theta's polynomials.

## Appendix C: Stock of total Vacancies with and without correction for newborn firms.

### Total Vacancies with and without correction for newborn firms' vacancies



## Appendix E: Stock of total Vacancies for assuming alternative distributions for expansion vacancies.

### Total Vacancies for different distributions

