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Modeling of the entrepreneurial survival equation of medellín's industrial sector*

Julián Santiago Vásquez Roldán, Robert Ng Henao*****

Abstract

Introduction. The intention of this work is to invetigate the probability of survival of the new companies created in the Medellín Industrial sector between the years 2000 and 2010. Also to highlight some determinants of the factors of success in the consolidation and acceptance of companies in the Market, in the time lapses immediately following their gestation. **Objective.** Calculate the cumulative survival rate of companies belonging to the Industrial sector of the city of Medellín created in the period between 2000 and 2010. Considering the size, legal nature and industrial sector to which it is circumscribed. **Materials and methods.** To account for the objective was used the survival function in a certain period shows the percentage of companies alive after a certain number of periods after their appearance. The risk function shows the percentage of companies closing t periods of time after its birth. **Results.** The risk of disappearance of a company decreases as the antiquity increases, additionally, is smaller in companies that are born with a larger or big size. The creation of companies is greater among the smaller ones, but present higher mortality rates in the first years of life. The survival of new companies is positively related to their size at birth.

Keywords: business creation, multivariable regression models, business survival, smes, industrial sector.

Supervivencia empresarial: el caso del sector industrial en Medellín

Resumen

Introducción. El propósito del presente trabajo es el de investigar la probabilidad de supervivencia de las nuevas empresas creadas en el sector industrial de Medellín entre los años 2000 y 2010. Así mismo evidenciar algunos determinantes de los factores de éxito en la consolidación y aceptación de las empresas en el mercado, en los periodos de tiempo inmediatamente posteriores a su gestación. **Objetivo.** Calcular la tasa acumulada de supervivencia de las empresas pertenecientes al sector Industrial de la ciudad de Medellín creadas en el período comprendido entre los años 2000 y 2010. Esto teniendo en cuenta el tamaño, naturaleza jurídica y sector industrial al que se circunscriben. **Materiales y métodos.** Para dar cuenta del objetivo se utilizó la función de supervivencia en un cierto período muestra el porcentaje de empresas vivas después de que transcurran un número determinado de períodos tras su aparición. La función de riesgo muestra el porcentaje de empresas que cierra t períodos después de su nacimiento. A su vez, la función de supervivencia recoge el porcentaje de empresas vivas t períodos después del nacimiento. **Resultados.** El riesgo de desaparición de una empresa disminuye conforme aumenta la antigüedad, adicionalmente, es menor

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** GINVECO Group researcher at the Faculty of Economics, Autónoma Latinoamericana University email julian.vasquez@unaula.edu.co

*** GINVECO Group researcher at the Faculty of Economics, Autónoma Latinoamericana University email robert.nghe@unaula.edu.co

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Autor para correspondencia: Julián Santiago Vásquez Roldán, email: julian.vasquez@unaula.edu.co

en las empresas que nacen con un mayor tamaño. La creación de empresas es mayor entre las de menor tamaño, pero presentan mayores tasas de mortalidad en los primeros años de vida. La supervivencia de las nuevas empresas se encuentra positivamente relacionada con su tamaño al nacer.

Palabras clave: creación de empresas, modelos multivariables de regresión, supervivencia empresarial, Pymes, sector industrial.

Supervivência empresarial: o caso do setor industrial de medellín

Resumo

Introdução. O propósito do presente trabalho é o de investigar a probabilidade de supervivência das novas empresas criadas no setor industrial de Medellín entre os anos 2000 e 2010. Assim mesmo evidenciar alguns determinantes dos fatores de sucesso na consolidação e aceitação das empresas no mercado, nos períodos de tempo imediatamente posteriores à sua gestação. **Objetivo.** Calcular a taxa acumulada de supervivência das empresas pertencentes ao sector Industrial da cidade de Medellín criadas no período entre os anos 2000 e 2010. Isto tendo em conta o tamanho, natureza jurídica e setor industrial ao que se circunscrevem. **Materiais e métodos.** Para dar conta do objetivo se utilizou a função de supervivência num certo período de amostra a porcentagem de empresas vivas depois de que transcorram um número determinado de períodos após sua aparição. A função de risco mostra a porcentagem de empresas que fecha t períodos depois do seu nascimento. Por sua vez, a função de supervivência recolhe a porcentagem de empresas vivas t períodos depois do nascimento. **Resultados.** O risco de desaparição de uma empresa diminui conforme aumenta a antiguidade, adicionalmente, é menor nas empresas que nascem com um maior tamanho. A criação de empresas é maior entre as de menor tamanho, mas apresentam maiores taxas de mortalidade nos primeiros anos de vida. A supervivência das novas empresas se encontra positivamente relacionada com seu tamanho ao nascer.

Palavras chave: criação de empresas, modelos multi-variáveis de regressão, supervivência empresarial, Pymes, setor industrial.

Introduction

In survival analyzes the most important variable is the time under which the possible occurrence of a particular event is determined (Molinero, 2001). A possible method to develop this analysis is to assume that these times follow a specific type or specific model of mathematical distribution (Daly, Hathaway, Kuruvadi, Callon, Hughes, Pinch, & Galli, 1985). In this sense, the most appropriate procedure, according to Kleinbaum (1996) is to propose a model of how the mortality rate evolves according to a particular period of time. Once the mortality rate is determined, the survival function is calculated from said rate, which can be adapted not only to the clinical context but also to the business context (Segarra, Arauzo, Gras, Manjón, Mañé, Teruel, & Theilen, 2002).

According to Pol (1993), the objective of most survival models is to determine a mortality rate, which can also be referred to as a hazard function and is usually represented as λ(t). From the clinical perspective, as well as from business applications, the simplest case corresponds to considering that the hazard function does not change over time, but is rather constant (Molinero, 2001), with which can be verified that the survival function would be given by the equation 1:

$$\boldsymbol{S(t)} = e^{-\lambda * t}. \text{ (equation 1)}$$

However, the most frequent case is that the mortality rate or hazards function, presents modifications in its final value as a function of the time elapsed since the beginning of the observations (Abraira, Ortuño, Quereda, & Fernández, 1996).

In this case, an adaptation that can be used for generating greater reliability to the survival functions, in view of the difficulties involved in the management of nonlinearities, and as a function of the finding of the adjustment parameters, is the distribution of Waloddi Weibull (Dhillon, 1999). Under this distribution, the extreme values of the function are linked to the useful life of the subjects under study, where it can be concluded that changes in the parameters of the function generate a set of distributions similar to those of an exponential, gaussian or chi-square distribution (Olivares-Pacheco, Cornide-Reyes & Monasterio, 2010). The use of the Weibull distribution in survival functions, would allow its restructuring in the following functional form (Sanz, González-Loureiro, & Blanco, 2013) equation 2:

$$\boldsymbol{\lambda}(\boldsymbol{t}) = c * m * t^{m-1} \text{ (equation 2)}$$

For an application of business survival, adapted to the general context of Medellin's industrial fabric between 2000 and 2010, it is interesting to model not only the relationship between the survival rate of companies and time, but also the possible relationship with different variables recorded for each business sector (NG-Henao, 2015). It is therefore a question of calculating the mortality rate as a function of time and of prognostic variables, beyond the estimators normally used through Kaplan - Meier 's traditional survival functions (1958).

The central concept of a survival model is not the probability that a change of state occurs, for example, the probability that a company closes, but rather the conditional probability of a change of state occurring, given that it had another previous state, that is, a company closure given that in the previous period, it had not done so (Ayala & Borges, 2007, p.32).

The fundamental idea in the modeling that is intended for the analysis of business survival in Medellin's industrial sector between 2000 and 2010, is the same as in any regression model and although there are different alternatives, the model selected to obtain the highest degree of reliability through the adaptation of estimators used in human survival, is the so-called proportional hazards or Cox model (Nikulim & Wu, 2016), in which the mortality rate is estimated a equation 3:

$$\boldsymbol{\lambda}(\boldsymbol{t}, \boldsymbol{x}_{\mathbf{1}} .. \boldsymbol{x}_{\mathbf{p}}) = \lambda_0(t) * e^{b1*x1+b2*x2+\cdots bp*xp}$$

(equation 3)

In this case, the estimation of survival results from the product of two components, $\lambda_0(t)$ that depends on time, and the other e^{b*x} which depends on the prognostic or covariant variables, and does not depend on time (Therneau & Grambsch, 2000).

The use of such a model for business survival estimation includes the coexistence of risks for two different sets of values of the covariates that retain the same proportion over time (Rodriguez, 1999); hence the name of proportional risk models (Molinero, 2001). Thus, for example, if one of the prognostic variables was to count on areas of research, development and innovation, coded as 0 and 1, keeping the remaining covariates the same, we can calculate the values of the term e^{b*x} for companies with and without areas of research, development and innovation, obtaining two different numbers: 1 for the absence of areas of R + D +i ($e^0 = 1$) and if, for example, for companies it were 2 , according to this model, that over time the mortality rate of organizations is always double than that of companies that do not adapt to the context of competitiveness through the strategic generation of conditions of research, innovation and development, that is to say for those that had the parameter e^0 with a lower estimation value.

This characteristic of the risk proportionality model for different groups of covariates must be kept in mind when applying the technique to the data inventory and the selection of variables that determine the survival of the economic sector that is intended to be analyzed, since it is not always valid. This is the case when the influence of some variant depends precisely on time (Nikulim & Wu, 2016).

In this modeling aimed to establish the measurement of business survival through the use of Cox regressions, $\lambda_0(t)$ represents the hazard function when all covariates are 0, or risk when there is no physical sense that any of the variables is 0 (Therneau & Grambsch, 2000).

For the estimation of a proportional hazards model, a mathematical model could be postulated for the specific survival function, which will deepen the generation of degrees of reliability, for example Weibull (Fritsch, Brixy & Falck, 2006). However, the approach proposed by Cox is based on the fact that the form of $\lambda_0(t)$ is often unknown and is not of primary interest, since the real objective is to assess the influence of prognostic factors on survival

(Headd, 2003). Therefore, the Cox model does not determine $\lambda_0(t)$ (Bates, 2005).

According to the model of Molinero (2001), established for the analysis of human survival, the interpretation of the coefficients estimated by the Cox regression method is straightforward, and resembles the results that a logistic regression model would yield (Ortega & Cayuela, 2002) $Exp(bi)$ where bi is the coefficient corresponding to the variable Xi, and it is the relative risk when Xi increases one unit, keeping the others constant.

Materials and methods

Taking Molineros' proposal (2001), attempting to model this application of the clinical context to the business context, and seeking to establish the hazard and survival rate, the coefficient, standard error and chi² is offered for each variable involved in the equation, which allows to calculate the level of probability for said coefficients (Lunn & Mcneil, 1995).

The adaptation of the results, in function of three variables considered as determinants of the business survival of Medellin's industrial sector companies is achieved through the use of the equation 4:

$$\boldsymbol{\lambda(t, x_1 .. x_p)} = \lambda_0(t) * e^{b1*x1+b2*x2+\cdots bp*xp}$$

(equation 4)

Offering the following results:

Table 1. Initial estimation of the relationship between experience, tax regime and innovation capacity as determinants of business survival through the proportional hazards method

Term	Coef.	Std. Err.	Wald chi²	p	Signif. Level
Experience	0.1291	0.0232	10.738	0.0017	p < 0.01
Tax system	-0.0387	0.3516	0.011	0.9180	NO
Capacity for Innovation	1.0642	0.4046	7.268	0.0091	p < 0.01

Source: Own elaboration

The regression data shown in Table 1 demonstrate, through the use of the proportional hazards model, that there is no relationship between the tax regime and survival, whereas the probability values indicate a significant association between the survival of Medellin's Industrial companies in the period 2000-2010 and the other two variables: market experience and capacity for innovation.

The result offered by the regression is much better if a relative risk table is presented with its 95 % confidence interval (Therneau & Grambsch, 2000).

Table 2. Initial estimation of the relationship between experience, tax regime and innovation capacity as determinants of business survival through the estimation of relative risks

Variable	Relative risk	RR inf.95%	RR sup.95%
Experience	1.12	1.04	1.19
Tax system	0.95	0.38	2.40
Capacity for Innovation	2.90	1.34	6.28

Source: Own elaboration

As expressed by Ortega and Cayuela (2002), the relative risk is calculated as $Exp(bi)$. A relative risk of 1 corresponds to a coefficient of 0 for that variable, and if it is a dichotomous characteristic (e.g., market experience, high - more than one year - or low - less than one year), the hazard is the same for companies with or without the presence of the factor of analysis. A risk greater than 1 indicates greater risk for companies with this characteristic. Thus in our case, companies with no experience, equal to other factors, have a risk 2.9 times greater than those that do not have a greater potential in terms of skills and innovation capacity.

The event whose possible appearance in time has been studied does not necessarily have to be the disappearance or closure of the firm. In this example, there could be a critical situation or an imbalance in market participation (Van Praag, 2003).

Model of analysis and determination of variables

The variables that can be used as covariates in the explanation of the survival conditions for a specific economic sector in time, as it is intended for Medellín's industrial sector city between the years 2000 and 2010, can be defined taking into account: a) the conceptual and operational definitions offered in the literature; B) the model to be used and the proposals to be validated; And c) the availability of information related to the environment, both sectoral and local (Gimeno, Folta, Cooper & Woo ,1997).

The estimation of the model under the multilinear and reliability context of the Cox regressions tries to analyze the influence of the sectoral and geographic environment conditions on the entry of new companies to the market, reason why this entry E can be analyzed from a general model of the form (Lin, 1994):

$$\boldsymbol{E} = f(sector, region)$$

Where the *sector* variable corresponds to the characteristics of the economic sector in which the new company is born (for the present analysis, this corresponds to the industrial sector) and the variable *region* corresponds to the conditions of the local environment in which that company is created (for the present analysis, this corresponds to the municipality of Medellín).

In this case, the general model takes the form of a linear regression equation 5:

$$\boldsymbol{\lambda(t, x_1..x_p)} = ENTRY - EXIT$$

(equation 5)

Where the functions corresponding to $ENTRY$ and $EXIT$ are equation 6 y 7:

$$\boldsymbol{ENTRY} = c + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + e$$

(equation 6)

$$\boldsymbol{EXIT} = \lambda_0(t) * e^{b1*x1+b2*x2+\cdots bp*xp}$$

(equation 7)

Therefore, the Cox proportional hazard function applied to business survival would initially be defined by equation 8:

$$\boldsymbol{SURVIVAL} = \lambda(t, x_1..x_p) =$$
$$(c + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + e) - (\lambda_0(t) * e^{b1*x1+b2*x2+\cdots bp*xp})$$

(equation 8)

Where:

- x_1: vector of variables that reflect characteristics of the economic activity sector.
- x_2: vector of variables that reflect the characteristics of the geographical area.
- x_3: vector of variables that characterize the sector of activity in the geographical area of reference of the company.
- x_4: vector of dummy variables that were used as control variables.
- *c:* constant.
- *e:* error term.

The linear regression model allows for directly interpreting the effect of environmental conditions analyzed, on the entry of new companies into the market, through the behavior and significance of the coefficients *b* (Lane, Looney & Wansley, 1986).

The contribution that this paper intends to offer focuses on the inclusion of the dependent variable $ENTRY$, which corresponds to the rate of entry of new organizations of an industrial nature to the market. This referring to the population occupied in the region where they are located, in this case the city of Medellín, according to the expression $c + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + e$ for the period corresponding to the years 2000 to 2010. The reasons for preferring the economic sector and the region of influence when considering the entry rate are multiple; however, the following two reasons stand out (Nikulim & Wu, 2016):

a. Several recent studies analyzing the effect of sectoral and territorial variables on entry rates, consider the existence of a positive correlation as a function of the entry of new companies and the evolution of their human capital based on better conditions of education and skills development associated with research and innovation (Armington & Acs, 2002; Keeble & Walker, 1994);
b. The rate of entry of new business organizations to a particular industry is correlated to sectoral specialization and government support in terms of reducing tax impact (Fritsch, Brixy, & Falck 2006).

Variables combining the sectoral and regional levels and configuration of the role of proportional risks (cox regression) for the measurement of business survival

Survival models provide techniques to analyze the follow-up time from an initial observation time to the occurrence of an event of interest, a follow-up time that can be observed completely or partially (Kantis & Federico, 2007).

For the case of the study mentioned the origin coincides with the creation of the company (entry) and the event is usually the death of the company (exit). The focus of the analysis is on the time between entry and closure (NG-Henao, 2015).

The central concept of a survival model is not the probability that a change of state occurs, for example, the probability that a company closes, but rather the conditional probability of a change of state occurring, given that it previously had another state over time, that is, a company closure given that in the previous period had not done so (Ayala & Borges, 2007).

For the present model, it is intended to offer a variation to the traditional survival estimators through the use of the Kaplan-Meier method (Kaplan & Meier, 1958) where according to Ng-Henao (2015) the probability that an individual enterprise (or a group of companies) finishes its activity during a certain exercise "t" will be a function of the risk that falls on the company (hazard rate). The risk rate of the active companies in "t-1" that managed to survive in "t" is expressed as follows equation 9:

$$\boldsymbol{h(t)} = 1 - \left[\frac{S(t)}{S(t-1)}\right] \quad \text{(equation 9)}$$

This expression, according to the contributions of Harris & Hassaszadeh (2002), establishes the probability that a company of "t-1" years will leave the market during the period "t". If time adopts a discrete dimension, the risk rate *h(t)* Reflects the probability that a company that has survived to exercise "t" Exit the market in the period "t + Δt" as can be seen in the following equation 10:

$$\boldsymbol{h(t)} = \lim_{\Delta t \to o} \left(\frac{P(t \leq T \leq t + \frac{\Delta t}{T} \geq t}{\Delta t} \right)^{1} = \mathrm{f(t)/S(t)}$$

(equation 10)

where $t = 1,2,...T$, is discrete time; *f(t)=dF(t)/dt* is the density function corresponding to the distribution of the outputs with respect to the initial number of companies in the group;*F(t)=Pr(T<t)* is the probability that the companies of the group reach a vital period "T" inferior to "t"; and, lastly, *S(t)=1-F(t)* Is the survival function (Dolton & Van Der Klauw, 1995).

The Cox proportional or regression risk function applied to the business survival derived from this research exercise has the advantage that it is not only a multi-linear estimator of the proportional risk of firms remaining in a given economic sector, At the same time, it includes the configuration of an estimator of the entry and creation of new companies, relating a specific group of variables associated with the sector (Industrial) and the region (municipality of Medellín). The equation would be initially defined by equation 11:

$$\boldsymbol{SURVIVAL} = \lambda(t, x_1 .. x_p) = (c + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + e) - (\lambda_0(t) * e^{b1*x1+b2*x2+\cdots bp*xp})$$

(equation 11)

Where:

- x_1: ***INTKATIN:*** *Intensity of capital invested in industrial activity*
- x_2: ***DEBT****: Average level of financial leverage of companies in the industrial sector.*
- x_3: ***PROFITABILITY****: Margin average price / cost of the companies that are part of the industrial sector.*
- x_4: ***SIZE****: Average size of the companies that are part of the industrial sector.*
- x_5: ***GDPGROWTHTH****: Influence of growth in production levels and / or per capita income for the municipality of Medellín in the two years prior to the entry of a firm in the market corresponding to the industrial sector.*
- x_6: ***KATHUM****: Effects of variation on human capital.*
- *c:* constant.
- *e:* error term.

Based on the proposed analysis model and the explicit definition of the variables, and after verifying the existence of serious problems of multicollinearity according to the correlation matrix, the Cox regression model for the measurement of business survival would be:

$$\boldsymbol{SURVIVAL} = \lambda(t, x_1 .. x_p) = (c + b_1INTKATIN + b_2DEBT + b_3PROFITABILITY + b_4SIZE + b_5GDPGROWTH + b_6KATHUM + e) - (\lambda_0(t) * e^{b1INTKATIN+b2DEBT+b3PROFITABILITY+b4SIZE+b5GDPGROWTH+b6KATHUM})$$

Results

For the year 2000 the expression 1-λ is equal to 0,9636. Then cumulative survival rate in the year 2000 is equal to 1-λ, that is to say 0,9636. For the year 2001 the value of 1-λ is equal to 0.8739, Therefore if we multiply this value by the accumulated survival rate of the previous year we can observe that the survival rate for the year 2001 will be equal to 0.8392, that is to say an accumulated survival rate for companies in the industrial sector of the Medellin city of 83.92 %. According to the methodology proposed, we can observe the results between 2000 and 2010.

Analyzes the survival of companies in the industrial sector of Medellin, created between 2000 and 2010

Year	Parameter 1-λ	Survival Rate
2000	0.9603	0.9603
2001	0.8739	0.8392
2002	0.9036	0.7583
2003	0.9506	0.7208
2004	0.9661	0.6964
2005	0.9462	0.6589
2006	0.9744	0.6420
2007	0.9645	0.6192
2008	0.9728	0.6024
2009	0.9766	0.5883
2010	0.9548	0.5617

Source: Self made.

A detailed examination of the cumulative average for the disappearance and liquidation of the companies born in the period between the years 2000 and 2009, allows establishing that on average 3 years after the birth of this cohort of productive structures, 26.5 % of the companies disappeared, after 7 years 42.7 %, and 9 years later, 47.5 % of the companies disappeared.

Mortality of the industrial companies created in Medellín in the period 2000-2009

Mortality rates of companies created during	Years after creations									Total closures to 2009
	1 years	2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years	
2000	12,6	9,6	4,9	3,4	5,4	2,6	3,6	2,7	2,3	47,1
2001	12,6	9,5	7,2	4,4	4,9	3,4	2,5	2,3		46,8
2002	13,2	11,1	8,6	4,6	3,5	3,0	3,6			47,7
2003	12,3	8,3	7	6,2	4,8	4,7				43,3
2004	10,9	7,8	6,7	3,7	4,9					34,1
2005	10,1	7,8	7	6,5						31,3
2006	10,4	7,6	6,2							24,2
2007	8,9	10,3								19,2
2008	11									11
2009	5,1									5,1
accumulated average	10,7	19,7	26,5	31,3	36,	39,4	42,7	45,2	47,5	

Source: Commercial Public Registry. Cámara de Comercio de Medellín para Antioquia. Own calculations

With respect to the application of the methodological framework proposed for the calculation of the business survival of the companies of the industrial sector of the Medellín city between the years 2000 and 2010, the following aspects can be concluded:

- The probability of failure and closure of a company is reduced as the permanence in the market increases and is less in the productive structures or ventures that since their appearance in the market they do with a big size.
- The difficulties of permanence of the companies are associated in a high percentage to the incidence of the phase of the economic cycle that is going through and to the projections of economic growth towards the short and medium term.
- In an economic context such as that of the Medellín city, it is too high the number of companies that are created with relatively small sizes, however, these types of ventures are those that concentrate the highest levels of probability of failure in their first years of operation.
- The survival rate of new entrepreneurial ventures is positively correlated with their size at birth. As the business size increases, the probability of survival of the company is much bigger. It is a stylized fact documented in the literature on business mobility, with many papers reaching the same conclusion.

References bibliographical

- Abraira, V.; Ortuño, J.; Quereda, C. & Fernández, M. (1996). Curvas de supervivencia y modelos de regresión: errores y aciertos en la metodología de aplicación. *Nefrología*, 16(5), 383-90.

- ANDI. (2011). *Encuesta de Opinión Industrial Conjunta*. Bogotá: Fondo de Publicaciones.
- Arias, A. & Quiroga, R. (2008). Cese de actividades de las pymes en el área metropolitana de Cali (2000-2004): Un análisis de supervivencia empresarial. *Cuadernos de Administración*, 35(1), 249-277.
- Arauzo, J.; Manjón, M.; Martín, M. & Segarra, A. (2002). *Entradas y Salidas de Empresas: Un Constraste de la Hipótesis de Independencia, Simetría y Simultaneidad*. España: Universitat Rovira iVirgili. Facultad de Ciencias Económicas y Empresariales. 29p.
- Armington, C. & Acs, Z. (2002). The determinants of regional variation in new firm formation. *Regional studies*, 36(1), 33-45.
- Audretsch, D. B. (1995). *Innovation and industry evolution*. Cambridge: Mit Press.
- Ayala, M. & Borges, R. (2007). *Análisis de supervivencia aplicado a la Banca Comercial Venezolana 1996-2004*. Mérida, Venezuela: Instituto de Investigaciones Económicas y Sociales, Universidad de Los Andes.
- Bates, T. (2005). Analysis of young, small firms that have closed: delineating successful from unsuccessful closures. *Journal of Business Venturing*, 20(3), 343-358.
- Behrens, K. (2004). Agglomeration without trade: how non-traded goods shape the space-economy. *Journal of Urban Economics*, 55(1), 68-92.
- Belleflamme, P.; Picard, P. & Thisse, J. (2000). An economic theory of regional clusters. *Journal of urban economics*, 48(1), 158-184.
- Bercovitz, J. & Mitchell, W. (2007). When is more better? The impact of business scale and scope on long-term business survival, while controlling for profitability. *Strategic Management Journal*, 61-79.
- Daly, P.; Hathaway, D.; Kuruvadi, S.; Callon, M.; Hughes, T.; Pinch, T. & Galli, I. (1985). *The biotechnology business: a strategic analysis (No. E14 A164)*. ABT Associates, Cambridge, Mass. (EUA). Robert R. Nathan Associates (EUA). AID, Washington, DC (EUA).
- Dhillon, B, S. (1999). *Design reliability fundamentals and applications*. United States of América: CRC Press.
- Dolton, P., And Von Der Klauw, W. (1995). Leaving Teaching in the UK: A Duration Analysis. *Economic Journal,* 105(429), 431-444.
- Echavarría, J.; Arbeláez, M. & Rosales, M. (2006). La productividad y sus determinantes: el caso de la industria colombiana. *Desarrollo y Sociedad*, *57*, 77-122.
- Fritsch, M.; Brixy, U. & Falck, O. (2006). The effect of industry, region, and time on new business survival–a multi-dimensional analysis. *Review of industrial organization*, 28(3), 285-306.
- Galor, O. & Moav, O. (2006). Das human-kapital: A theory of the demise of the class structure. *The Review of Economic Studies*, 73(1), 85-117.
- García, B. (2001). El sistema de innovación regional en una economía global: El caso de la Comunidad Foral de Navarra. En Olazaran, M., Gómez, M. (eds.). *Sistemas Regionales de Innovación*, Servicio Editorial de la Universidad del País Vasco, Leioa, (Bizkaia), 279-298.
- García, J.; Ríos, C. & Callejas, R. (2010). Desempeño financiero empresarial en Colombia en 2009: un análisis por sectores. *Perfil de coyuntura económica*, (15), 149-170.
- Gimeno, J., Folta, T.; Cooper, A. & Woo, C. (1997). Survival of the fittest? Entrepreneurial human capital and the persistence of underperforming firms. *Administrative science quarterly*, 750-783.
- González-Loureiro, M. & Puig, F. (2015). Challenges in internationalization and survivalof new manufacturing enterprises. *Cuadernos de Administración* (Universidad del Valle), 31(54), 7-15.
- Harris, R. & Hassaszadeh, P. (2002). The Impact of Ownership Changes and Age Effects on Plant Exits in UK Manufacturing, 1974-1995. *Economics Letters*, 75, 309-317.
- Headd, B. (2003). Redefining business success: Distinguishing between closure and failure. *Small Business Economics*, 21(1), 51-61.
- Kantis, H. & Federico, J. (2007). Los determinantes del surgimiento de nuevas empresas altamente dinámicas. Una comparación internacional. Universidad Nacional de General Sarmiento: Laboratorio de Investigación sobre Tecnología, Trabajo, Empresa y Competitividad, Littec.
- Kaplan, E. & Meier, P. (1958). Nonparametric estimation from incomplete observations. *Journal of the American Statistical Association*, 53, 282, 457-481.
- Kaplan, E. & Meier, P. (1958). Nonparametric Estimation from incomplete Observations. *Journal of the American Statistical Association*, (53), 457-481.

- Keeble, D. & Walker, S. (1994). New firms, small firms and dead firms: spatial patterns and determinants in the United Kingdom. *Regional studies*, 28(4), 411-427.
- Kleinbaum, D. (1996). *Statistics in the health sciences: Survival analysis.* New York: Springer_Verlag; 1996
- Lane, W.; Looney, S. & Wansley, J. (1986). An application of the Cox proportional hazards model to bank failure. *Journal of Banking & Finance*, 10(4), 511-531.
- LEE, E. (1992). *Statistical methods for survival analysis*. Second edition. New York: .John Wiley and Sons.
- Lunn, M., & Mcneil, D. (1995). Applying Cox regression to competing risks. *Biometrics*, 524-532.
- Molinero, L. (2001). *Modelos de regresión de Cox para el tiempo de supervivencia*. España: Asociación de la sociedad española de Hipertensión. Alce Ingeniería.
- Nikulin, M. & Wu, H. (2016). *The Cox Model and Its Applications*. Heidelberg: Springer-Verlag Berlin DOI 10.1007/978-3-662-49332-8
- NG-Henao, R. (2015). Marco metodológico para la determinación de la tasa de supervivencia empresarial en el sector industrial de la ciudad de Medellín en el periodo 2000-2010. Clio América, 9(18), 112-121.
- Nuez, M. & Górriz, C. (2008). Análisis de supervivencia de nuevas empresas. In *Universidad, Sociedad y Mercados Globales* (pp. 423-436). Asociación Española de Dirección y Economía de la Empresa (AEDEM).
- Olivares-Pacheco, J.; Cornide-Reyes, H. & Monasterio, M. (2010). An extension of the two-parameter Weibull distribution. *Revista Colombiana de Estadística*, 33(2), 219-231.
- Ortega, M., & Cayuela, A. (2002). Regresión logística no condicionada y tamaño de muestra: una revisión bibliográfica. *Revista Española de Salud Pública*, 76(2), 85-93.
- POL, A. (1993). Modelo de Regresión de Cox: Ejemplo numérico del proceso de estimación de parámetros. *Psicothema*, 5(2), 387-402.
- Prentice, R. & Williams, B. & Peterson, A. (1981). On the regression analysis of multivariate failure time data. *Biometrika,* 68(2), 373-379.
- Puig, F.; González-Loureiro, M. & Ghauri, P. (2014). Internationalisation for survival: the case of New Ventures. *Management International Review*, 54(5), 653-673.
- Rodríguez, A. (1999). Aplicaciones del análisis de supervivencia a la gestión de recursos humanos. In La gestión de la diversidad: *XIII Congreso Nacional, IX Congreso Hispano-Francés, Logroño* (La Rioja), 16, 17 y 18 de junio, 1999 (pp. 139-142). Universidad de La Rioja.
- Rodríguez, A.; Arias, A.; Charterina, J.; Jung, A.; Olarte, F.; Peña, I. & Saiz, M. (2008). *Creación, supervivencia, crecimiento e internacionalización de las PYME jóvenes en España entre los años 1995 -2006*. Madrid: Dirección general de política de la PYME. Ipyme.
- Santarelli, E. & Vivarelli, M. (2007). Entrepreneurship and the process of firms' entry, survival and growth*. Industrial and Corporate Change*, 16(3), 455-488.
- Sanz, S., González-Loureiro, M. & Blanco, F. (2013). El efecto" economía social" en la supervivencia empresarial. *CIRIEC-Espana*, (78), 175.
- Segarra, A. (2002). *Supervivencia empresarial, ciclo de vida y régimen tecnológico*. España: Universitat Rovira i Virgili. Facultad de Ciencias Económicas y empresariales. 26p.
- Segarra, A.; Arauzo, J. (2002). Las barreras a la entrada de empresas: ¿Importa el tamaño?. Ponencia del *V Encuentro de Economía Aplicada* - Oviedo (Junio). Disponible en: http://www.revecap.com/veea/autores/A/arauzo1.html
- Segarra, A.; Arauzo, J.; Gras, N.; Manjón, M.; Mañé, F.; Teruel, M. & Theilen, B. (2002). *La creación y la supervivencia de las empresas industriales*. Madrid: Civitas.
- Soubeyran, A. & Thisse, J. (1999). Learning-by-doing and the development of industrial districts. *Journal of urban economics*, 45(1), 156-176.
- Sutaria, V. & Hicks, D. (2004). New firm formation: Dynamics and determinants. *The Annals of Regional Science*, 38(2), 241-262.
- Stam, E.; Thurik, R. & Van Der Zwan, P. (2010). *Entrepreneurial exit in real and imagined markets*. Industrial and Corporate Change, dtp047.
- Therneau, T.; Grambsch, P. (2000). *Modeling Survival Data: Extending the Cox Model*. Springer-Verlag New York. DOI 10.1007/978-1-4757-3294-8
- Van praag, C. (2003). Business survival and success of young small business owners*. Small Business Economics*, 21(1), 1-17.