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A generalized method for valuing agricultural farms under uncertainty

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ABSTRACT

The opacity of the farm market means that valuations are based primarily on expert estimates rather than on actual transaction prices. The valuation method based on the two cumulative distribution functions (VMTCDF), created by Ballestero (1971), improves the synthetic method based on estimating the market value of an asset by establishing a proportional relation between the asset and one external variable. However, in most cases the expert must consider multiple external variables. This paper proposes a definitive extension to k indexes with a methodology particularly applicable to the field of valuation of non-market goods or markets where little information is available as may be the case with the valuation of agricultural land. The contribution is illustrated with an empirical example.

1. Introduction

The ideal scenario for an appraisal is to have enough information about comparable samples, and then apply different methods as, for example, the comparative method that is one of the classical methodologies in general valuation, Pagourtzi et al. (2003). In the field of land valuation, the valuation methods are classified as comparative methods, income methods and cost methods, Yomralioglu and Nisanci (2004). The application of a particular valuation methodology will depend on the aim of the valuation, property type and land use (Dale and McLaughlin, 1988; Wyatt, 1997) but data availability is also an important factor.

Indeed, Caballer (1999) highlighted the superiority of econometric valuation methods, (Hass, 1922; Ezequiel, 1926; Wallace, 1926; Renshaw, 1958; among others) compared to analytical and comparative methods, but he also recognized that its application is fundamentally limited due to the lack of data and transparency in the land market. In fact, the description given by Britton in 1951 is still valid and the land market is still opaque: transactions are not frequent and usually there is no information about prices or conditions. Aznar and Guijarro (2004) stated that in many occasions the appraiser does not know with certainty the value of the price or the exogenous variables, as their value can vary with time (for example, with the production of land) or because it is information not directly observable (risk of frost, quality of land, etc.) and it is usual to approximate with the mean value, Aznar and Guijarro (2004).

In this situation, commonly known as an uncertainty environment, it may be more natural to work with an interval instead of a central value, making the interval narrower as the certainty increases. When there are no available statistics, it is a usual practice to ask an expert in the specific field, similar to what occurs in program evaluation and review technique (PERT). Ballestero (1971) [pp.226] stated that "Frequently, statistics about transactions provide the minimum, maximum and likely prices. The same reason that justifies the use of the beta distribution for the calculation of activity times in PERT justifies the use of the beta distribution for this valuation methodology". This was the origin of the valuation method based on the two cumulative distribution functions (VMTCDF) (initially presented by Ballestero (1973) as the beta method and renamed by Herrerías and Herrerías (2010) to reaffirm the possibility of using different distributions).

This method, inspired by PERT, uses only the information, provided by an expert, about the minimum value (a), the maximum value (b) and the most likely value (m) of the asset and one external variable. This is its principal advantage since it can be applied in an uncertain environment where no information is available. The VMTCDF is considered by Aragones-Beltran et al. (2008) as one of the most widely used comparative methods together with synthetic methods (Ballestero and Romero, 1992) and econometric methods (Murray, 1969).

However, a disadvantage is that the original beta method provides a value for the asset based on a unique explanatory variable, leading to

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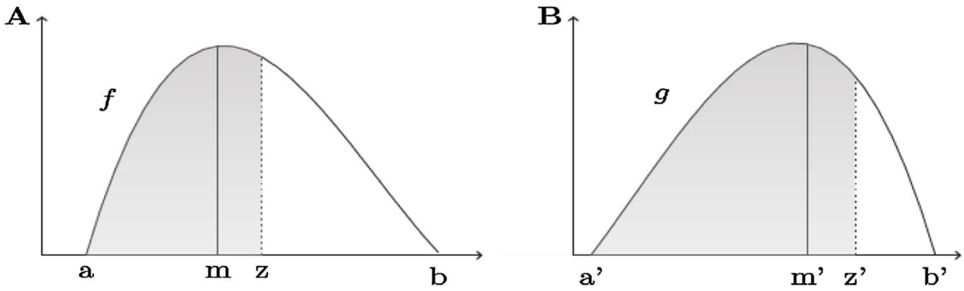

Fig. 1. Probability density functions of an asset (A) and an index (B) where it is verified that $\int_a^z f(x)dx = \int_{a'}^{z'} g(x)dx$.

different values for the asset for every explanatory variable introduced. Thus, this methodology does not lead to a unique value for the asset and it makes it difficult to decide how to combine them, Aragones-Beltran et al. (2008). That is, each explanatory variable leads to a value for the asset establishing a proportional relation between the cumulative distribution function of the asset and every external variable.

In most cases, the expert must consider multiple external variables. Actually, there are numerous references that advise the use of more than one index such as Hass (1922) who first applied regression techniques to land valuation, selecting four explanatory variables. Caballer (1999) valued almond farms based on three variables (economic yield, risk of frost and plantation age), Segura et al. (1998) valued citrus farms using four variables (surface, weather, location characteristics and the electrification of the plantation), Calatrava and Cañero (2000) considered three variables (surface, land quality and location of the farm), Maddison (2000) indicated that the climate, soil quality and elevation are important characteristics together with the structural attributes of the farmlands in England and Wales, Henning et al. (2001) showed that rural agricultural land values in the sugarcane submarket area of Louisiana are influenced by thirteen factors and Nilsson and Johansson (2013) analyzed significant factors in agricultural land prices in Sweden, with a particular focus on location-specific elements.

For this reason, it is necessary to jointly use all the information from the external variables to obtain a unique value for the asset. This fact justifies the multi-index extension of the beta method since, in most cases, the expert must consider multiple external variables (see e.g., García et al., 2002b; Herrerías and Herrerías, 2010 ; Franco et al., 2015). The way to combine the information of two indexes in the beta valuation method has been explained in García (2000), García et al. (2002a), Herrerías (2002), García et al. (2002b), García et al. (2004), and Herrerías and Herrerías (2010). All these attempts are based on subjective techniques or econometrics and only allow using two explanatory variables.

In this paper, we propose the extension to k indexes with a methodology that aims to be objective and that is particularly applicable to the field of valuation of non-market goods or markets where little information is available, as may be the case in the valuation of agricultural farms. The procedure consists of the construction of a weighted cumulative distribution function, collecting information about all the indexes and establishing a correspondence with the cumulative distribution function of the asset to estimate its value.

The work is structured as follows: in the methodology section, we first review the main concepts of the valuation method of the two cumulative distribution functions (VMTCDF) and present the proposed methodology with four steps: generation of data through directional regression, specification of the model from the weighted cumulative distribution function (WCDF), the estimation of the model with NNLS algorithm and finally the estimation of the values for the asset. We illustrate the results of this paper in Section 3 with an empirical application. Finally, principal conclusions are presented.

2. Methodology

The beta method was officially presented in Ballestero (1973). Later, Palacios et al. (2000) found a theoretical basis for the valuation method of the two cumulative distribution functions (VMTCDF): "*By considering the variable I, which represents a quality index of the asset, and the variable V, market value of the asset, it is supposed that the market value is related to the quality index,* i.e.*,* $V = \Phi(I)$*, where* Φ *is a strictly increasing function in the interval* $[I_1; I_2]$*. If the cumulative distribution function of the index I is G(i), then V is a random variable whose cumulative distribution function is*

$$F(v) = P(V \le v) = P(\Phi(I) \le v) = P(I \le \Phi^{-1}(v)) = G(\Phi^{-1}(v))$$

or equivalently,

$$G(i) = P(I \le i) = P(\Phi(I) \le \Phi(i)) = P(V \le \Phi(i)) = F(\Phi(i))$$

where Φ *is a strictly increasing distribution function. Furthermore, it is clear that if F is strictly increasing over the interval* $(\Phi(I_1), \Phi(I_2))$ *then F is invertible over the same interval. Then, it is possible to describe a bijection* Φ: $(I_1, I_2) \to (\Phi(I_1); \Phi(I_2))$ *defined by* $\Phi(i) = F^{-1}(G(i))$ *which converts the value of an index into a market value for the asset.*" Then, if the index is I_0 then the market value of the asset is obtained as

$$V_0 = \Phi(I_0) = F^{-1}(\mathrm{G}(I_0)) \tag{1}$$

García and García (2003) showed that it is possible to establish a bijection between the value of the index *z'*, and the value of the asset, *z*, when the minimum (*a, a'*), maximum (*b, b'*) and most likely (*m, m'*) values of the index and the asset are provided by an expert, see Fig. 1. Note that it is a usual practice to work with the standardized variable $t = \frac{x-a}{b-a}$ leading to a minimum value of zero, to a maximum value of 1 and to a standardized likely value equal to $M = \frac{m-a}{b-a}$.

If more than one external variable is applied, the VMTCDF provides values for the asset as external variables are introduced. This paper proposes to extend this methodology to construct a joint distribution function for all the explanatory variables and apply the correspondence with the cumulative distribution function of the asset to obtain the corresponding unique value for the asset. With this purpose, a weighted cumulative distribution function will be constructed from the relevance (p_i) of every index over the assets. Prior to this, it will be necessary to generate a data set that allows the estimation of a regression whose estimated parameters will be the weights of the indexes (p_i). Once the p_i are estimated, it will be possible to construct the joint distribution function and apply the extension of the VMTCDF to obtain the estimation for the value of the asset. Fig. 2 illustrates the procedure of the proposed methodology, which will be explained in detail in the following subsections.

2.2. A joint distribution function from a weighted cumulative distribution function

The concept of a weighted cumulative distribution function (WCDF) for two variables was presented in García et al. (2002b), where the