SERIE DOCUMENTOS DE TRABAJO

FACULTAD ECONOMÍA Y NEGOCIOS UNIVERSIDAD DE CHILE

DEPARTAMENTO DE ECONOMÍA

SDT 372

THE INSURANCE VALUE OF FORESTS IN SUPPLYING CLIMATE REGULATION

Autores: Eugenio Figueroa B. y Roberto Pasten

Santiago, Diciembre de 2012

The insurance value of forests in supplying climate regulation

Eugenio Figueroa B. Roberto Pasten C.[b1*]

[a] *Department of Economics, Universidad de Chile, Santiago, Chile;* [b] *Department of Economics and Finance, Universidad de Talca, Talca, Chile*

Abstract: This brief paper proposes an analytical method for estimating the economic value of forest ecosystems in supplying climate regulation. If, as argued by several authors, forests ecosystems serve as hedging against climatic risk, then natural ecosystems may act as substitutes for market insurance. This ecosystem service of climate regulation can be economically valued by the marginal reduction in the willingness of risk-averse individuals to pay to avoid risk. We formally develop this novel methodology. As an illustration, we provide an estimate of the insurance value of climate regulation provided by forests using data on insurance premiums paid by local Chilean farmers. The insurance value of climate regulation is estimated to be approximately USD 0.0733 per hectare of forest. The framework that is proposed in this paper is useful and relevant for the cost-benefit analysis of natural resource conservation investments.

Keywords: Ecosystem services; insurance value; climate regulation; economic valuation

JEL Classification: Q51, G2

[1*] Corresponding author: Universidad de Talca, 2 Norte 685, Talca, Chile. Tel: 56 71 200308 Fax: 56 71 200457. E-mail: rpasten@utalca.cl.

1. Introduction

Extreme climatic events, such as droughts, heat waves, excessive precipitations and large storms, as well as large natural disasters, such as floods, landslides and earthquakes, typically result in significant human casualties and economic damage (Loayza et al. 2009, Cavallo and Noy 2010).[2] These events have large welfare costs for people who would willingly pay to avoid such disasters. For example, Barro (2009) has shown that society would willingly reduce its GDP by approximately 20% per year to eliminate large-scale economic cost such as those caused by natural disasters. On a local geographical scale, extreme climate events can also cause significant economic losses and human casualties with considerable human welfare costs. Moreover, because biodiversity and ecosystems provide local climate regulation (IPCC 2007, MEA 2005, West et al. 2011), these systems reduce local climate variability and the probability of extreme climatic events at the local level. Thus, through the provision of climate regulation ecosystem services, natural ecosystems play a role that is similar to that of financial insurance by helping in hedging the risk of agents whose outcomes depend on climate distribution (for example, farmers). The theory that natural ecosystems reduce variability in the provision of ecosystem services and are thus valuable to risk-averse individuals was first proposed by Baumgärtner (2006). This paper applies Baumgartner's idea to estimate empirically the economic value of climate regulation that is provided by natural ecosystems. To the best of our knowledge, this paper is the first attempt to present a methodology for estimating the economic value of climate regulation.

[2] Among climatic extreme events, heat waves often claim the largest number of fatalities (Gabriel and Endlicher 2012). And natural disasters, including extreme climatic events, imposse a disproportionate share of their effects on people in developing countries (Kahn 2005).

Researchers have conducted empirical studies about risk-averse farmers facing production or revenue risk , but crop diversification rather than ecosystem is used as a hedging mechanism. (Smale et al 1998; Zhu et al 2000; Di Falco and Perrings, 2003, 2005; Swanson and Goeschl, 2003).

The study of the economic value of ecosystem services that affect the variance and higher moments of the benefit distribution of economic agents is underdeveloped in both environmental and insurance economics, and this brief paper is a first step in filling this gap. In the following section, we develop a simple model of risk-averse farmers who face a climatic risk which is negatively related to the size of an ecosystem. In section 3, as an illustration, we report empirical estimates of the insurance value of climate regulation based on information drawn from a survey of climate insurance paid by Chilean farmers. Finally, section 4 concludes.

2. **The insurance value of ecosystem climate regulation services**

Through its effects on the exchange of energy, humidity, carbon, and other elements (Oke, 1982 and 1987; Bonan, 2008; Heisler 1986), the size of an ecosystem provides natural insurance against weather variability, particularly against extreme climatic events. Thus, an ecosystem provides insurance value beyond the conventional (more extensively studied) economic value (use and non-use values). The theoretical foundations for the estimating strategy we use here are provided by the theory of the insurance value of biodiversity proposed by Baumgärtner (2006) and the theory of competitive supply by risk-averse farmers developed by Newbery and Stiglitz (1981).

According to the expected utility paradigm, individuals who are facing risk can be characterized as maximizing $Eu(x+\tilde{y})$, i.e., the expected value of the utility, u, of the sure income x and the risky outcome $\tilde{y}$. In this paper, we postulate that the riskiness of the outcome decreases with the size of the ecosystem which provides the local climate regulation services, and we refer to this property as *the insurance value of the ecosystem*. Note that the introduction of risk decreases total utility if $Eu(x+\tilde{y})-u(x)<0$, which is only true if $u(x)$ is concave (i.e., the individual is risk-averse). The difference $Eu(x+\tilde{y})-u(x)$ is a measure of the cost of the risk in terms of the expected utility loss.

However, a second measure of the cost of the risk is given by the risk premium $\pi(x,\tilde{y})$ that makes the agent indifferent between receiving the risk $\tilde{y}$ and receiving the non-random amount $E(\tilde{y})-\pi(x,\tilde{y})$. By the properties of utility,

$$Eu(x+\tilde{y})=u(x+E(\tilde{y})-\pi(x,\tilde{y})) \quad (1)$$

Because the agent is indiferent between receiving the risk $\tilde{y}$ and receiving for sure the amount $\hat{y}=E(\tilde{y})-\pi(x,\tilde{y})$, this amount is called the certainty equivalent.

When risk $\tilde{y}$ is unfavorable, the insurance premium $\pi_I(x,\tilde{y})$ is the amount that makes the decision maker indifferent between facing the risk $\tilde{y}$ and paying the non random amount $\pi_I(x,\tilde{y})$. Because paying π_I is equivalent to receiving $-\pi_I$, Pratt (1964) shows that

$$\pi_I(x,\tilde{y})=\pi(x,\tilde{y})-E(\tilde{y}).$$

We assume that the risk $\tilde{y}$ is actuarily fair (i.e. $E(\tilde{y})=0$) and thus, the risk premium and the insurance premium coincide.

Assuming that a farmer lives for only one period and that his production function is given by $\tilde{q} = f(\mathbf{z}, \tilde{\varepsilon}, \varphi)$, where output $\tilde{q}$ is a function of inputs $\boldsymbol{z}$ (an n-dimensional vector), the state of weather is described by the random variable $\tilde{\varepsilon}$, and the production technique is φ. For a given technique, we assume that the risk is additive, such that the following equations hold true:

$$\tilde{q} = f(\boldsymbol{z}) + k\tilde{\varepsilon}; \quad E\tilde{\varepsilon} = 0; \quad Var\ \tilde{\varepsilon} = \sigma_\varepsilon^2$$

E is the expectation operator and the parameter k is the size of the additive risk. Thus, the output is random with a mean of $E\tilde{q} = f(\boldsymbol{z}) = \bar{q}$ and a variance of $Var\ \tilde{q} = k(s)^2\sigma_\varepsilon^2$. Our main hypothesis in this paper is that the size of risk k decreases as the size of ecosystem s increases, such that $k'(s) < 0$. This ability of the ecosystem to reduce climatic risk is what the literature calls the climate regulation ecosystem service provided by natural ecosystems (MEA 2005, Oke, 1982 and 1987; Bonan, 2008; Heisler 1986). Below we propose and apply an econometric procedure to empirically estimate the economic value of this ecosystem service.[3]

A farmer's net income is given by the following expression:

$$\tilde{x} = N + (p - c)\tilde{q} = N + (p - c)\bar{q} + (p - c)k(s)\varepsilon \qquad (2)$$

where N is non-farm income, p is the exogenously determined price faced by farmers and c is the constant average cost (per unit of output). Thus net income $\tilde{x} = x + \tilde{y}$ is a random variable itself with

[3] We have assumed that the variance – rather than the mean – of the climate regulation services that are provided by ecosystems is affected by s through the parameter k. In a more general setting, the mean may also be affected by s, but we focus on the second moment rather than the first moment of the climate distribution. The extension to cases in which the mean depends positively of ecosystem size is straightforward.

$$x = N + (p - c)\bar{q} \text{ and } \tilde{y} = (p - c)k(s)\varepsilon \quad (3)$$

In the present context, a second potential source of systematic and non-systematic (background) risk is price variability in the agricultural sector, as discussed extensively by Newbery and Stglitz (1981). The present article does not directly address the issue of price variability because our main focus is climate variability. However, the price variability of agricultural commodities may become a relevant issue if severe climatic events affect individual supply, and these shocks can affect prices to the extent that they are correlated through the market. We assume that prices are exogenously given and consequently uncorrelated with output. This assumption is valid if the correlation of weather in the various production areas is low and transport costs are high. In the particular context of Chile, where we empirically apply our model, this assumption appears to be valid given the geographical conformation of the country and the widely separated areas in which the diverse crops are produced. However, in a more general conceptual framework, if the objective is to obtain an accurate measure of the insurance value of climate regulation, then the issue of two correlated sources of risk (output and prices) due to climatic shocks should be explored.[4]

Net income $\tilde{x}$ is used to purchase c units of consumption at a given price of p_c; thus, a farmer faces the following budget constraint: $p_c c \leq \tilde{x}$. Based on the assumption that the utility function is given by a monotonic and concave function $U(c)$ and a employing a normalizing consumption price $p_c = 1$, the budget constraint becomes $c = \tilde{x} = x + \tilde{y}$, and as a result of this, the expected utility can be written as

[4] See the work of Newbery and Stiglitz (1979) for a theory of commodity price stabilization.

$$EU(\tilde{x}) = EU(x + \tilde{y}) \tag{4}$$

We assume that (4) is a von Newmann-Morgenstern utility function that represents the risk preferences of a farmer who maximizes the expected value of the utility that he obtains from the random variable $\tilde{x}$.

According to Pratt (1964), the risk premium in (1) is as follows:

$$\pi(x, \tilde{y}) \cong -\frac{1}{2}\sigma_y^2 \frac{U''(x)}{U'(x)} = \frac{1}{2}A\sigma_y^2 \tag{5}$$

where $A = -\frac{U''(x)}{U'(x)}$ corresponds to the coefficient of absolute risk aversion. Using the fact that the variance of net income σ_y^2 is given by $(p - c)^2 k^2(s)\sigma_\varepsilon^2$, and the fact that risk is actuarily neutral by assumption and thus insurance premium and risk premium coincide and using (5) we are able to show that insurance premium is given by:

$$\pi(s) = (p - c)^2 k^2(s) A\sigma_\varepsilon^2 \tag{6}$$

Thus, the farmer's willingness to pay to avoid random climatic shocks (the insurance premium) increases with the coefficient of absolute risk aversion A, with the variance of climatic risk σ_ε^2, with the size of the risk $k(s)$ (which is a function of the ecosystem size s) and with the square of profits per unit of output $(p - c)$. Moreover, equation (6) is the functional form that links the risk premium $\pi(s)$ to the size of the natural ecosystem. Taking the derivative of (6) with respect to s, we obtain the following expression:

$$\frac{\partial \pi(s)}{\partial s} = (p - c)^2 k k'(s) A\sigma_\varepsilon^2 \tag{7}$$

which is negative if the ecosystem provides the climate regulation ecosystem service (i.e $k'(s) < 0$). Thus, for a risk-averse farmer, the risk premium is decreasing in the ecosystem size s.

2.1. Method

The calculation of an exact measure of the marginal economic value of the climate regulation services in (7) is nearly impossible. However, we can obtain some information about its magnitude by observing the actual behavior of farmers facing real-life decisions with regard to avoiding the effects of climate shocks. The observed insurance premium that is paid by farmers by an insurance policy that protects them against extreme climatic events can be viewed as the maximum premium that he/she is willing to pay to avoid a lottery with risk size $k\tilde{\varepsilon}$. According to our previous results, the observed risk premium paid ($\pi(s)$) must be a decreasing function of the ecosystem size (s). Thus, the empirical relationship between the risk premium and the size of an ecosystem can theoretically be determined by running the following regression:

$$\pi_i = g(\boldsymbol{\beta}, s, \boldsymbol{X_i}) + \epsilon_i \qquad (8)$$

Where π_i is the insurance premium that is paid by farmers, $\boldsymbol{\beta}$ is a vector of parameters to estimate, s_i is the ecosystem size, $\boldsymbol{X}_i$ denotes other control variables and ϵ_i is the error term.

To use a flexible functional form in (8), we employ a Box-Cox transformation (Box and Cox, 1964), which allows the optimal functional form to be derived from the data rather than merely imposing such a form a priori. In this context, regression (8) is expressed as

$$\frac{\pi_i^{\lambda}-1}{\lambda} = \alpha + \beta\left(\frac{X_i^{\lambda}-1}{\lambda}\right) + \gamma\left(\frac{s_i^{\lambda}-1}{\lambda}\right) + \epsilon_i \quad (9)$$

where λ, α, β, and γ are parameters to be estimated; π_i is total insurance premium per hectare that is paid in municipality i of a total of 146 municipalities in the Chile agricultural zone; X_i is the mean size of the insurance policy in municipality i (the total insured value divided by the number of insurance policies that are paid in municipality i) and it is included to account for the insurance subsidy that is given by the government to the farmers, which decreases with the size of an insurance policy and renders this insurance more expensive for larger policies. Thus, β is expected to be significant and positive. Because in our empirical work we are studying the climate regulation ecosystem services provided by forests, the variable s_i corresponds to the area covered by forest ecosystems (both native and exotic) as a proportion of the total area of municipality i.Therefore, the crucial empirical test of the hypotheis of the insurance value of the climate regulation ecosystem service of forests implies that the estimated value of γ obtained from the econometric estimation of (9) should be significant and negative.

Because the transformation in (9) embeds several popular functional forms, this method has received a significant amount of attention as a means of seeking the most empirically appropriate functional form in each case. In particular, if $\lambda = 1$, then expression (9) collapses to a linear regression, such that the following equation holds true:

$$\pi_i = \alpha + \beta X_i + \gamma s_i + \epsilon_i \quad (10)$$

The expression collapses to a log-linear regression when $\lambda = 0$ as follows:

$$\ln(\pi_i) = \alpha + \beta\ln(X_i) + \gamma\ln(s_i) + \epsilon_i \quad (11)$$

To empirically run the regressions in (9) to (11), we obtain data on climate insurance (premiums paid, crop areas covered and average amount insured for 2006) from a database that is maintained by the Agricultural Insurance Commission (COMSA) in Chile. This insurance covers losses that are caused by a lack or excess of rain, damaging winds, snow, hail and ice, and the insurance applies to operations in some valleys of Chile's regions I and III and V to X regions for a broad range of crops[5]. Data on forest coverage are obtained from the Forestry National Corporation (CONAF), and data on municipality areas are obtained from the National Institute of Statistics (INE). Two municipalities (Limache and Ancud) are eliminated after controlling for outliers.

The results for the three econometric specifications – the linear form, the logarithmic form, and the more general lambda-model of a Box-Cox regression – are reported in columns 2, 3 and 4 of Table 1, corresponding to equations 10, 11 and 9, respectively. In addition, Table 2 reports the results of the likelihood-ratio tests for three standard functional specifications: multiplicative inverse ($\lambda = -1$), natural logarithmic ($\lambda = 0$), and linear ($\lambda = 1$).

TABLE 1 ABOUT HERE

TABLE 2 ABOUT HERE

As shown in Table 1, the econometric estimations render the correct positive sign for the mean size of the insurance policy and the correct negative sign for the size of the forest ecosystem in the three models estimated; moreover, all the estimated

[5] Further details can be found at www.seguroagricola.com.

coefficients are highly significant at the 1% level. However, in the Box-Cox transformation model (column 4), the lambda transformation does not significantly add to the regression. This last result is confirmed by Table 2, which shows that both the linear and multiplicative inverse specifications are strongly rejected; however, the natural logarithmic specification cannot be rejected at the 5% cutoff point. Thus, the data render the natural logarithmic specification (column 3 in Table 1) as the best empirical model. With this model as a benchmark, Figure 1 is drawn free of the effect of 'mean policy' X_i and depicts the relationship between the log of π_i and the log of s_i and thus the log of the insurance premium paid for the climate insurance and the log of the ecosystem size, respectively.

FIGURE 1 ABOUT HERE

3. Estimation of the insurance value of climate regulation ecosystem service

The insurance value of the climate regulation ecosystem service $V(s)$ provided by the forest ecosystem size s is the functional form that links the risk premium π to the size s of the ecosystem as follows:

$$V(s) = -\frac{\partial \pi(s)}{\partial s} \qquad (12)$$

The insurance value of the ecosystem size $V(s)$ evaluated at the mean value of the premium $\bar{\pi}$ (not scaled by the area covered) and the ecosystem size $\bar{s}$ (not scaled by the municipality area) for the general form of the Box-Cox transformation in (9) is expressed as follows:

$$V(s) = -\frac{\partial \pi(s)}{\partial s} = -\gamma \left(\frac{\bar{s}}{\bar{\pi}}\right)^{\lambda - 1} \qquad (13)$$

Thus, using the results of the regression of the natural logarithmic model in column 3 of Table 2, we obtain $\lambda = 0$ and $\gamma =$ - 0.25; using our database, we obtain $\bar{s}$=28 701 and $\bar{\pi}$ = 86.52. Thus, the insurance value of climate regulation is - 0.25(86.52/28,702) = UF 0.0008, indicating that an additional hectare of forest ecosystem reduces the insurance premium amount that is paid by farmers by UF 0.0008 per year.[6] Moreover, because the average percentage of public subsidies for agricultural insurance policies in Chile is about 50 % of the gross premiums paid, it is possible to estimate the total (a farmer's costs in addition to subsidy costs) absolute value of a marginal hectare of forest ecosystem in UF as 0.0016 per year. Furthermore, because the total surface of the forests that are included in the protected areas between the V and X regions of Chile (the regions in which most of the agricultural insurance is actually applied) is 2,659,924 hectares, the total value of the "climate regulation" services that are provided by forest ecosystems in these protected areas is estimated to be USD 126,346 per year. Table 3 translates these marginal and total values to Chilean pesos (CH$) and North American dollars (USD) for 2009.

4. Conclusions

Despite the growing evidence of the influence of ecosystems and biodiversity on local, regional and global climate in the last decade, few insurance and environmental economics studies have investigated the role of ecosystems as insurances against extreme climatic events (shocks). Moreover, there is no formal framework for estimating the economic value of the 'climate regulation' ecosystem service as described by the specialized literature (MEA 2005, Oke, 1982 and 1987; Bonan, 2008; Heisler 1986). To our knowledge, this article is the first attempt to develop a

[6] A UF (Unidad de Fomento) is an inflation-corrected constant unit of value that is used in Chile, and its (nominal) value was CH$21,454.86 on December 30, 2010. The exchange rate for the same date was US$468.37 per Chilean peso (source: Central Bank of Chile).

formal economic framework for empirically estimating the insurance value of the local climate regulation provided by natural areas (forest cover specifically).

Empirical estimates of the marginal and total economic value of climate variability regulation services are undoubtedly important for conservation as well as restoration policy evaluation and implementation. Using a survey of the insurance premiums paid by farmers in Chilean agriculture, we estimated the marginal value of one hectare of a forest ecosystem as a provider of climate regulation as approximately US$ 0.0733. Although this marginal value may appear rather small, when it is applied to value the climate regulation service provided by the natural forest ecosystems included in the National System of Protected Areas of Chile, the total annual flow is of US$ 194,951, an amount that seems to be consistent with ecosystems whose climate effects are expected to be larger on a global scale than on a local scale. Thus, the theoretically consistent and expected quantitative estimations obtained in this study are interesting and useful because these results provide empirical evidence of the local climate regulation services provided by forest ecosystems. These findings are undoubtedly useful from a policy perspective because the economic valuation of these ecosystem services provides a benchmark that is necessary to assessing prospective social investments for protecting and/or restoring natural areas. Moreover, the results of this study clearly show that the economic value of local climate regulation ecosystem services, albeit small, differs from zero and may be significant for large ecosystem areas. Finally, this study also attempts to contribute to satisfying the urgent need to advance our understanding of the role of biodiversity and ecosystems in determining climate, especially local climate conditions (The Royal Society 2008, IPCC 2007), for which objective empirical evidence is crucial.

References

Barro, R.: 2009, Rare disasters, asset prices, and welfare costs, The American Economic Review 99(1), 243.264.

Baumgärtner S. 2006. The insurance value of biodiversity in the provision of ecosystem services. Department of Economics, University of Heidelberg, Germany. pp. 36.

Bonan, G. 2008. Forest and Climate Change: forcings, feedbacks and the climate benefits of forest. Science 320: 1444- 1449.

Box, G.E.P., Cox, D.R. 1964. An analysis of transformations. Journal of the Royal Statitical Society, Series B, 211-243.

Cavallo, E., Noy, I. 2010. The economics of Natural Disasters: A Survey. IDB Working Papers Series N° IDB-WP-124. pp. 50. Inter American Development Bank; Washington D.C.

Di Falco S., Perrings C. 2003. Crop genetic diversity, productivity and stability of agroecosystems: a theoretical and empirical investigation. Scottisch Journal of Political Economy 50 (2), 207-216.

Di Falco S., Perrings C. 2005. Crop biodiversity, risk management and the implications of agricultural assistance. Ecological Economics 55(4), 459-466.

Heisler, G. 1986. Energy savings with trees. Journal of Arboriculture 12 (5):113–125.

Gabriel, K. M.A. and Endlicher, W. R. 2012. Urban and rural mortality rates during heat waves in Berlin and Brandenburg, Germany. *Environmental Pollution, 159: 2044-2050.*

IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment. Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.

Kahn, M. E. 2005. The death toll from natural disasters: The role of income, geography, and institutions. *Review of Economics and Statistics*, 87(2): 271–284.

Loayza, N., Olaberría, E., Rigolini, J, Christiaensen, L. 2009. Natuaral Disasters and Growth: Going beyond de Averages. Policy Research Working Paper N° 4980. pp. 40. The World Bank; Washington D.C.

MEA. 2005. Ecosystems and Human Well- Being: Current State and Trends. Millennium Ecosystem Assessment. Island Press, Washington, DC.

Newbery D.M.G, Stiglitz J.E.1979. The theory of commodity price stabilization rules: Welfare impacts and supply responses. The Economic Journal (89), 799-817.

Newbery D.M.G, Stiglitz J.E.1981. The theory of commodity price stabilization. Claredon Press, Oxford.

Oke, T. R. 1982. The energetic basis of the urban heat island. Quarterly Journal of the Royal Meteorological Society 108 (455):1–24.

Oke, T. R. 1987. Climate of Non-Uniform Terrains; in T. R. Oke, Boundary Layer Climates, Second edition. Routledge, University Press, Cambridge. Pags. 158 – 189.

Pratt, J.W. 1964. Risk aversion in the small and in the large. Econometrica 32, 122-136.

Smale, M., Hartell J., Heisey P.W. and Senauer B. 1998. The contribution of genetic resources and diversity to wheat production in the Punjab of Pakistan. American Journal of Agricultural Economics 80, 482-493.

Swanson T., Goeschl T. 2003. Pests, plagues, and patents. Journal of the European Economic Association 1, 561-575.

The Royal Society. 2008. Biodiversity-climate interactions: adaptation, mitigation and human livelihoods. The Clyvedon Press Ltd., Cardiff, UK.

West P. C., Narisma G. T., Barford C. and Kucha C. J. 2011. An alternative approach for quantifiying climate regulation by ecosystems. Frontiers in Ecology and the Environment **9**: 126–133.

Zhu, Y., Chen H., Fan J., Wang Y., Li Y., Chen J., Fan J.X., Yang S., Hu L., Leung H., Mew T.W., Teng P.S., Wang Z., and Mundt C.C. 2000. Genetic diversity and disease control in rice. Nature 406, 718-722.

Table 1: Estimation of the climate regulation model

	Equation		
	linear	natural log	Box-Cox transformation
MEAN SIZE OF THE INSURANCE POLICY	0.0007 ***	0.57 ***	0.43***
	(4.39)	(7.79)	(48.3)
SIZE OF THE ECOSYSTEM	-1.00 ***	-0.25 ***	-0.28 ***
	(-5.61)	(-6.33)	(-35.3)
CONSTANT	0.76***	-4.03***	-3.61
	(11.02)	(-11.10)	
Lambda			0.04
			(0.58)
R^2	0.29	0.46	
Observations	146	146	146

OLS regressions. The dependent variable is RISK PREMIUM. t-statistic values are in parenthesis. ***,**, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Table 2: Likelihood ratio tests for three standard functional form specifications

Test Ho	Restricted Log likelihood	LR statistic chi2	P-value Prob>chi2
Lambda = -1	-104.7	174.0	0.00
Lambda = 0	-17.9	0.3	0.56
Lambda = 1	-88.7	141.9	0.00

Table 3: Marginal and total value of climate variability regulation services provided by forest and/or wetland ecosystems expressed in UF, CH$ and USD

	UF	CH$ 2010	USD 2009[7]
Marginal annual value per ha	0.0016	34.33	0.0733
Total annual value	4 256	91 309 275	194 951

[7] USD (2009) 1 = CH$ 468.37 (Central Bank of Chile)

Figure 1: Scatter plot of ecosystem size (in logs) and predicted and actual insurance premiums (in logs)