IMPACTS OF SEEDLING DONATION PROGRAMS ON THE PROFITABILITY OF REFORESTATION PROJECTS CONDUCTED BY SMALL AND MEDIUM SIZE FARMS, A STUDY OF CASES[1]

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Abstract

This paper analyzes the impacts of public and private seedling donation programs on the profitability of reforestation projects carried out on small and medium size Brazilian farms. Homogeneous eucalyptus tree plantations in the Brazilian states of Minas Gerais, São Paulo, and Paraná were used to supply our data. In these states, public and private seedling and input donation programs are conducted to stimulate tree planting. The main results of this paper are: (a) under deterministic conditions, seedling donation increases the profitability of reforestation projects by 8.3% in the state of Paraná and by 6.8% in the state of São Paulo; (b) donation of seedling and inputs increased reforestation profitability in the state of Minas Gerais' by 52.19% and 43.88% for projects MG3 and MG4 respectively. The above results confirm the importance of seedling donation in stimulating reforestation. The paper ends by giving some suggestions to improve this type of program.

Key words: Reforestation, profitability, seedling donation.

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1. Introduction

This paper evaluates the impacts of public and private eucalyptus seedling donation programs on the profitability of reforestation projects carried out on small and medium size farms in the Brazilian states of Minas Gerais, Paraná, and São Paulo.

Since the 1950s, each of these three states has had its own governmental, private, and civic programs to stimulate reforestation on small to medium size farms thorough the donation of tree seedlings and, occasionally, agricultural inputs. In some years, these programs have been responsible for 25% of the forests planted in these states (Néris, 2001).

An increase in the area annually planted in forests is essential if Brazil is to avoid a scarcity of roundwood in the near future (Bacha, 1999; SBS, 2000). Small and medium size farms are promising candidates for the task of bringing about this expansion. Capp Filho (1976) and Albuquerque (1993) evaluated the profitability of reforestation conducted on small and medium size farms in the state of Minas Gerais, as did Rodigheri & Pinto (1997) for the state of Paraná. However, these analyses are deterministic; and their methodology does not address the effect of risk and risk aversion or the importance of seedling donation programs. Both risk and the impact of seedling donation on profitability are evaluated in this paper.

In order to study comparable reforestation projects, our analysis only examines the main tree specie used for stimulated planting in these states: eucalyptus. According to the Associação Brasileira de Celulose e Papel (1998), eucalyptus was responsible for 62.3% of the stimulated planting conducted on small and medium size farms (with the support of paper and pulp enterprises) in the year 1998.

This paper is comprised of six sections, including this introduction. Section 2 shows the methodologies employed to evaluate the profitability of reforestation projects. Section 3 delineates the cases

under study, the data set, and some constrains that emerge in determinist analysis. The results from determinist analysis and the Monte Carlo simulations appear in sections 4 and 5 respectively. Section 6 ends the paper with our conclusion.

2. Methodologies for evaluating project profitability

There are methodologies for evaluating a project's profitability that do not take into account the opportunity cost of money over time, among them, the capital return time (simple payback, SPB). SPB measures the time needed for the investor to recover the initial capital invested. Despite its limitations, SPB can be useful as an additional indicator for evaluating project profitability.

According to Azevedo Filho (1995), Simple Payback (SPB) is calculated by using the following formula:

$$\text{SPB} = k, \text{ just as } \sum_{i=0}^{k} Li \geq 0 \text{ and } \sum_{i=0}^{k-1} Li < 0 \quad \text{where,}$$

Li = value of cash flow (receipt minus expenses) at time i.

More sophisticated techniques for selecting and evaluating projects take into account the opportunity cost of capital over time. They include mechanisms that devalue the cash flow of a project by using an interest rate, called the discount rate or the opportunity cost rate. Among the best known techniques for economic evaluation are Economic Payback (EPB), Internal Rate of Return (IRR), Present Value (PV), Benefit-Cost ratio (B-C ratio), Updated Total Cost (UTC), and Expected Value of the Land (EVL).

Economic Payback is given by the following formula:

$$\text{EPB} = k, \text{ just as } \sum_{i=0}^{k}\left[Li \Big/ (1+\rho)^{i} \right] \geq 0 \text{ and } \sum_{i=0}^{k-1}\left[Li \Big/ (1+\rho)^{i} \right] < 0$$

Where:
Li = net cash flow at time i (receipt minus expenses at time i),
ρ = discount rate.
The internal rate of return (IRR) is the interest rate that reduces the present value of a specific project's net cash flow to zero. In other words:

$$\text{IRR} = \rho^*, \text{ just as } \sum_{i=0}^{n} Li(1+\rho^*)^{-i} = 0$$

Where:
ρ^* = discount rate,
Li = net cash flow at time i (= receipts at time i minus expenses at time i).

According to Noronha (1988), a specific project is selected if its IRR is higher than the market interest rate; the latter representing the opportunity cost for an enterprise.

There are two major advantages in using IRR (Noronha, 1988): first, because IRR represents the investment's profit rate, it can be directly compared with the capital cost rate; second, it is unnecessary to assume an arbitrary discount rate in order to calculate IRR.

According to Capp Filho (1976), the present value (PV) of a cash flow is a number equal to the sum of the devaluing cash flow by using a specific interest rate. Use of the (PV) of a cash flow is considered to generate the most consistent results when evaluating unconventional projects.

The following formula can be used to calculate PV:

$$\text{PV} = \sum_{i=0}^{n} \frac{Li}{(1+\rho)^i}$$

Where:
ρ = discount rate
Li = net cash flow at time i (= receipts at time i minus expenses at time i).
n = economic life period.

It is necessary that PV > 0 in order for a project to be classified as economically viable.

The deficiencies of PV method appear when it is necessary to rank projects with distinct initial capital investments and periods of economic life. Moreover, the explanatory value of PV is very sensitive to the discount rate chosen.

Benefit-cost ratio (B-C ratio) is commonly used for product evaluation because it is easy to interpret. A specific project is refused if the B-C ratio is less than 1. According to Azevedo Filho (1995), B-C ratio is calculated by the following method:

$$\text{B-C ratio} = \frac{\sum_{i=0}^{n} \beta i \Big/ (1+\rho)^{i}}{\sum_{i=0}^{n} Ci \Big/ (1+\rho)^{i}}$$

Where:

βi = receipts at time i,

Ci = cost at time i,

ρ = discount rate.

p is an opportunity cost of capital and is used as a discount rate. The choice of p is somewhat arbitrary, one of the Benefit-Cost ratio's bias inducing limitations. Another limitation is the sensibility of the B-C ratio to both the project's dimension and its economic life span.

Updated total cost (UTC) is an auxiliary indicator that is useful for measuring the scale of a project. By using UTC, an investor can identify budget restrictions.

The following formula is used to calculate UTC:

$$\text{UTC} = \sum_{i=0}^{n} \frac{Ci}{(1+\rho)^{i}}$$

Where:
Ci = project's cost at time i,
ρ = discount rate.

According to Rodriguez et al. (1997, p. 18), "the omission [from consideration] of land use after finishing a rotation and different project economic life spans are the most serious consequences resulting from the choice of inappropriate indicators for the evaluation of reforestation projects." To avoid the first problem, the expected value of land (EVL) can be included in the evaluation, thereby assuming perpetual repetition of reforestation projects. The second problem can be eliminated by considering that a projects economic life tends toward infinity, thus developing a standardized economic life span that can be rationally justified for use in different analyses.

According to Rodriguez et al. (1997, p. 19), "the expected value of land is the sum of the present value of net proceeds obtained at the end of each rotation period for projects that continue perpetually."

EVL was calculated by using the following formula:

$$EVL = \frac{RLi}{\left[(1+\rho)^{i} - 1\right]}$$

Where:
RLi = net proceeds compounded at the end of each rotation period,
i = duration of each rotation period,
ρ = discount rate (remuneration rate of capital).

RLi is calculated by using the following formula:

$$RLi = (P - e)V_r(1+\rho)^{m-r} + (P - e)V_n(1+\rho)^{m-n} + (P - e)V_m - I(1+\rho)^{m} - \sum_{i=1}^{m} M_i(1+\rho)^{i}$$

Where:
RLi = net proceeds compounded at the end of each rotation period,
ρ = discount rate (remuneration rate of capital);
r = year of the first clear-cut;
n = year of the second clear-cut;

m = year of the third clear-cut;
I = implantation cost at year *0*;
M_i = maintenance cost at year i;
Vi = weight or amount of roundwood harvested at year j ($j = r, n, m$),
P = price of each unit of roundwood harvested,
e = harvest cost per unit of roundwood.

EVL assumes that the land will be used to conduct an infinite series of identical forest rotations. The present value of this series is an appropriate criterion for pricing land.

The idea behind EVL is to determine the present net income that can be obtained from an area, for example one hectare, that will be perpetually harvested and reforested. If this present net income is greater than the acquisition cost of land (ACL), a farmer will profit by buying the land and planting forest. In other words, a project is viable if EVL > ACL.

All the above indicators are used for evaluating the reforestation projects found in this study. This procedure allows the researcher to diagnose similarities and divergences when ranking the profitability of various projects according to specific, distinct indicators. DETERPRJ (System for Analyzing Deterministic Projects) is used for calculating indicator values.[4]

3. Analyzed projects and data source

This study analyzes the profitability of eucalyptus reforestation projects in specific regions of the states of São Paulo, Minas Gerais, and Paraná. Two conditions restrict the choice of study projects: first, only eucalyptus trees are considered because they are the most planted trees on small homogeneous plantings in the majority of our study area

[4] Additional information about this software can be found in Azevedo Filho. DETERPRJ – Manual do usuário - Versão 1.00. USP/CIAGRI. Piracicaba, 1995, 22 pages. This software is easily handled and it also permits one to calculate all profitability indicators except EVL. The latter is calculated by using Excel.

(pine trees are more frequently planted in only the state of Paraná); second, the projects are representative of the average area employed for stimulated tree planting.

In the state of São Paulo, the considered projects are in the regions of Penápolis, Assis, and Piracicaba. Information about agricultural procedures, technical coefficients, and productivity were collected from FLORESPI, a member of CONIN.[5] In the state of Minas Gerais' Vale do Rio Doce region, a project conducted by an industrial partner of the Forest Farmer Program was analyzed.[6] Information from the state of Paraná about agricultural procedures, technical coefficients, and productivity are based on a study by Rodigheri & Pinto (1997). Technical coefficients and productivity tables are from Néris (2001).

3.1 - Data considerations

3.1.1 – Costs of planting, maintenance, and clear-cut harvest

A 21-year crop rotation period with clear-cutting every seven years was considered in all regions. Due to the nature of eucalyptus, only seven year-old trees can be clear-cut to produce the firewood or chips that generate first revenues. The first year investment (year 0) is represented by planting costs. Harvest costs appear in the 7th, 14th, and 21st years. Maintenance costs arise in the 1st through the 21st year. Maintenance and clear-cut costs are measured at the end of the year that they are generated. The daily wage paid to unskilled workers in the state of São Paulo was adopted to determine the cost of employed labor and as the opportunity cost for use of family members.

[5] Forest Engineer Ricardo Otto Leão Schmdit gave the information.

[6] Domício Lott, Forest Operation Supervisor of an industrial enterprise that participates in the Forest Farmer Program, gave the information.

3.1.2 – Price of roundwood

For the cases from the states of Paraná and São Paulo, the price of eucalyptus firewood was considered. This price was provided by the Environment Institute of Paraná (IAP) and directly from sawmills in São Paulo. For Minas Gerais, the price actually paid by industry for pulp logs from the first and second clear-cuts was considered. For the third clear-cut, the price provided by the Minas Gerais State Institute of Forests (IEF) for eucalyptus firewood gathered on the farm was considered.[7]

3.1.3 – Discount rates

Discount rates were used for comparing the costs of each phase of reforestation in different time periods. The discount rate works as an opportunity cost and ranged from 6% to 20% per year, increasing by one percentage point in each consecutive year of our study. This makes it possible to evaluate the impact of increasing capital opportunity costs on the economic valuation of eucalyptus reforestation projects.

The opportunity cost of money was determined with reference to the most popular saving account in Brazil, which pays a real interest rate of 6% per year. Alternatively, the farmer can look for bonds that pay the same interest rate that the BNDES charges for its long-term loans, which, according to Machado (2000, p. 58), "ranged from 9.40% to 18.06% per year (plus the banking spread) between January 1996 and March 1999."

3.1.4 – Alternative reforestation projects

For each state, two alternatives seed procurement methods

[7] The same production system in the State of Minas Gerais can be used to produce firewood in all three clear-cuts. The sale of pulp logs in the first two clear-cuts only reflects market opportunities. There is coherency among the production systems of the three states analyzed. There is, however, only different destination for the logs.

were considered when forming cash flow projections. For the states of São Paulo (SP) and Paraná (PR), the two alternatives assume either that the farmers acquired seedlings through donations (projects SP1 and PR1) or by purchase (projects SP2 and PR2). This reflects the differences between programs that grant seedling and those that sell seedlings. The cost of log transportation from the farm to the consumer are considered consumer expenses and not included in the analysis of projects SP1, SP2, PR1, and PR2.

Both two alternatives created for the state of Minas Gerais assume seedling donation but condition different product sales schemes, which represent the peculiar features of Minas' Forest Farmer Program. In this program, the farmer receives free seedlings but must choose between different, well defined plans for log sales.

According to the rules of Minas Gerais' Forest Farmer Program, an industrial enterprise offers seedlings and agricultural inputs to the farmer to stimulate the latter to plant trees. In exchange, the farmer gives a percentage of the first clear-cut to the industrial enterprise, 6.25% in our study case, and is responsible for the clear-cutting, gathering, and transportation costs of R$ 7 per stereo of logs. The remaining production, 93.75% of the first clear-cut, must be sold to the industrial enterprise that supplied the inputs. In November 1999, these industries paid R$ 14.25 per stereo. The clear-cutting and gathering costs for this remaining production, R$ 4 per stereo in November 1999, are again the farmer's responsibility, but not transportation costs. The mandatory relationship between the farmer and the industrial enterprise ends after the first clear-cut, at the beginning of the 8th year. At that time, all project costs are shifted to the farmer, and the farmer is left free to sell the logs from the second and third clear-cuts in whatever manner he chooses.

The first project considered for the state of Minas Gerais (project MG1) assumes that the industrial enterprise contracts to buys the logs harvested in the first clear-cut, and the farmer sells the logs

from the second and third clear-cuts in the open market at a price of R$ 10 per stereo (November 1999 eucalyptus firewood price provided by the Minas Gerais State Institute of Forests). Clear-cut and gathering costs are R$ 4 per stereo. The second project for Minas Gerais (project MG2) assumes that the industrial enterprise buys both the first and second log harvests while the third harvest is sold in the open market.

Each of the six alternative projects was further subdivided by either the inclusion or exclusion of land costs from the analysis. The resulting twelve projects are presented in Figure 1.

Figure 1 – Features of the reforestation projects analyzed

	São Paulo		Minas Gerais		Paraná	
			With donation of seedling and agricultural inputs			
	With donation of seedlings	Farmers buy seedlings	Industrial enterprise buys only roundwood from the first clear-cut	Industrial enterprise buys roundwood from the first and second clear-cuts	With donation of seedlings	Farmers buy seedlings
Excluding land cost	SP1	SP2	MG1	MG2	PR1	PR2
Including land cost	SP3	SP4	MG3	MG4	PR3	PR4

4. Results of estimated indicators – deterministic analysis

Néris (2001) shows all data sets used for calculating the economic indicators. Table 1 shows the present project value according to different opportunity costs in R$ after discounting the cost of land. Shaded values refer to projects that were refused.

Table 1 – The present values (PV) of the reforestation projects (values in R$/ha) according to opportunity costs of 6% to 20% per year, excluding land costs. Values from November 1999

Opportunity costs (%)	Minas Gerais		Paraná		São Paulo	
	Industrial enterprise buys only roundwood from the first clear-cut	Industrial enterprise buys roundwood from the first and second clear-cuts	With donation of seedlings	Farmers buy seedlings	With donation of seedlings	Farmers buy seedlings
	MG1	MG2	PR1	PR2	SP1	SP2
6	2,275.64	2,913.58	1,333.25	1,204.94	2,347.77	2,201.13
7	2,019.29	2,578.67	1,150.37	1,022.06	2,063.56	1,916.92
8	1,793.96	2,285.05	991.89	863.58	1,816.56	1,669.92
9	1,595.06	2,026.71	854.00	725.69	1,601.05	1,454.41
10	1,418.78	1,798.64	733.56	605.25	1,412.28	1,265.64
11	1,261.94	1,596.61	627.97	499.66	1,246.32	1,099.68
12	1,121.90	1,417.09	535.06	406.75	1,099.89	953.25
13	996.42	1,257.08	453.01	324.70	970.25	823.61
14	883.63	1,114.04	380.32	252.01	855.08	708.44
15	781.93	985.83	315.70	187.39	752.45	605.81
16	689.97	870.60	258.08	129.77	660.72	514.08
17	606.59	766.77	206.54	78.23	578.48	431.84
18	530.80	672.99	160.32	32.01	504.54	357.90
19	461.74	588.09	118.75	-9.56	437.90	291.26
20	398.68	511.06	81.26	-47.05	377.69	231.05

Source: Néris (2001)

In Paraná, only project PR2 (farmers buy seedlings) is refused and only when interest rates are greater than 18% per year. For all opportunity costs, the projects based on the donation of seedlings are more profitable than the projects based on the farmers buying seedlings. In Minas Gerais, for all opportunity costs, the project is more profitable if the industrial enterprise buys both the first and second clear-cuts

rather than only the first clear-cut.

When land costs are including in implementation costs, PV is reduced (Table 2). However, projects MG3 and MG4 continue to be profitable for all interest rates considered. Projects PR3 and PR4 are refused when interest rates are equal or greater than 8% per year, and projects SP3 and SP4 are refused when interest rates are equal or greater than 10% per year.

Table 2 – Present values (PV) in R$/ha of the reforestation projects according to opportunity costs of 6% to 20% per year, including land costs. Values from November 1999.

Opportunity costs (%)	Minas Gerais		Paraná		São Paulo	
	Industrial enterprise buys only roundwood from the first clear-cut	Industrial enterprise buys roundwood from the first and second clear-cuts	With donation of seedlings	Farmers buy seedlings	With donation of seedlings	Farmers buy seedlings
	MG3	MG4	PR3	PR4	SP3	SP4
6	1,992.12	2,631.24	410.34	282.03	1,193.86	1,047.22
7	1,714.88	2,275.27	158.63	30.32	823.60	676.96
8	1,472.55	1,964.51	-55.89	-184.20	506.54	359.90
9	1,259.78	1,692.19	-239.49	-367.80	233.88	87.24
10	1,072.17	1,452.69	-397.28	-525.59	-1.59	-148.23
11	906.07	1,241.30	-533.45	-661.76	-205.79	-352.43
12	758.43	1,054.11	-651.45	-779.76	-383.57	-530.21
13	626.72	887.80	-754.10	-882.41	-538.98	-685.62
14	508.79	739.57	-843.76	-972.07	-675.36	-822.00
15	402.86	607.08	-922.36	-1,050.67	-795.47	-942.11
16	307.41	488.32	-991.53	-1,119.84	-901.65	-1,048.29
17	221.14	381.57	-1,052.62	-1,180.93	-995.83	-1,142.47
18	142.96	285.36	-1,106.76	-1,235.07	-1,079.66	-1,226.30
19	71.92	198.45	-1,154.90	-1,283.21	-1,154.51	-1,301.15
20	7.21	119.76	-1,197.85	-1,326.16	-1,221.56	-1,368.29

Source: Néris (2001)

Contrasting the PV results from Minas Gerais with those from the other states highlights the importance of future purchase contracts to the profitability of a reforestation project. When land costs are considered in the equations, the integration between industrial enterprises and farmers brought about by the purchase arrangement employed in Minas Gerais is even more important to project profitability.

Tables 3 and 4 show project benefit-cost ratios. Projects with a B-C ratio less than 1 are refused. When land costs are excluded (Table 3), only project PR2 is refused and only when interest rates are greater than 18% per year; all other projects show B-C ratios greater than 1 at all opportunity cost levels.

Table 3 – Benefit-Cost Ratio (B-C ratio) of the reforestation projects, considering opportunity cost from 6% to 20% per year and land costs are excluded. Values from November 1999

Opportunity costs (%)	Minas Gerais		Paraná		São Paulo	
	Industrial enterprise buys only roundwood from the first clear-cut	Industrial enterprise buys roundwood from the first and second clear-cuts	With donation of seedlings	Farmers buy seedlings	With donation of seedlings	Farmers buy seedlings
	MG1	MG2	PR1	PR2	SP1	SP2
6	1.62	1.79	2.44	2.14	3.25	2.85
7	1.60	1.77	2.32	2.02	3.11	2.70
8	1.58	1.74	2.20	1.90	2.97	2.56
9	1.56	1.71	2.08	1.79	2.83	2.42
10	1.54	1.69	1.98	1.69	2.70	2.29
11	1.52	1.66	1.87	1.59	2.57	2.17
12	1.49	1.62	1.77	1.50	2.45	2.05
13	1.47	1.59	1.68	1.41	2.33	1.94
14	1.44	1.56	1.59	1.33	2.22	1.84
15	1.42	1.53	1.51	1.25	2.12	1.74
16	1.39	1.49	1.43	1.18	2.01	1.64
17	1.36	1.46	1.35	1.11	1.92	1.55
18	1.34	1.43	1.28	1.05	1.82	1.47
19	1.31	1.39	1.21	0.99	1.73	1.39
20	1.28	1.36	1.15	0.93	1.65	1.32

Source: Néris (2001)

When land costs are included in implementation costs (Table 4), the projects can be ordered by benefit-cost ratio as follows (from best to worst): MG4, MG3, SP3, SP4, PR3, PR4. Projects PR3 and PR4 are refused when interest rates are greater than 7% per year; projects SP3 and SP4 are refused when interest rates are greater than 9% per year; project MG3 is refused when interest rates are greater than 19% per year. Project MG4 is economically viable for all interest rates considered...

Table 4 – Benefit-Cost Ratio (B-C ratio) of the reforestation projects, considering opportunity costs ranging from 6% to 20% per year and land costs are included. Values from November 1999

Opportunity costs (%)	Minas Gerais		Paraná		São Paulo	
	Industrial enterprise buys only roundwood from the first clear-cut	Industrial enterprise buys roundwood from the first and second clear-cuts	With donation of seedlings	Farmers buy seedlings	With donation of seedlings	Farmers buy seedlings
	MG3	MG4	PR3	PR4	SP3	SP4
6	1.49	1.65	1.18	1.12	1.45	1.37
7	1.46	1.61	1.07	1.01	1.31	1.25
8	1.42	1.56	0.97	0.92	1.20	1.13
9	1.39	1.52	0.89	0.83	1.09	1.03
10	1.35	1.48	0.81	0.76	1.00	0.94
11	1.32	1.44	0.74	0.69	0.92	0.86
12	1.28	1.39	0.68	0.63	0.84	0.79
13	1.25	1.35	0.62	0.58	0.77	0.73
14	1.21	1.31	0.57	0.53	0.71	0.67
15	1.18	1.27	0.53	0.49	0.66	0.62
16	1.14	1.23	0.48	0.45	0.61	0.57
17	1.11	1.18	0.45	0.42	0.56	0.53
18	1.07	1.14	0.41	0.39	0.52	0.49
19	1.04	1.10	0.38	0.36	0.48	0.45
20	1.00	1.07	0.35	0.33	0.45	0.42

Source: Néris (2001)

Tables 5 and 6 evaluate the projects from the perspective of the internal rate of return (IRR). When land costs are excluded from project start-up costs, only project PR2 is refused and only if the opportunity cost is above 20% per year (Table 5).

Table 5 – The internal rate of return (IRR) for the eucalyptus reforestation projects excluding land costs. Values from November 1999

	Minas Gerais		Paraná		São Paulo	
	Industrial enterprise buys only roundwood from the first clear-cut	Industrial enterprise buys roundwood from the first and second clear-cuts	With donation of seedlings	Farmers buy seedlings	With donation of seedlings	Farmers buy seedlings
	MG1	MG2	PR1	PR2	SP1	SP2
IRR	29.63	30.89	22.59	18.76	30.18	25.09

Source: Néris (2001)

As expected, IRR is reduced when land costs are added to implementation costs (Table 6). Only projects MG3 and MG4 are accepted at all interest rates. In Paraná, all projects are rejected if the annual interest rate is above 8%, while all projects become unprofitable in the state of São Paulo when interest rates are above 10%. Because of the relatively low cost of reforestation land in Minas Gerais, reforestation profitability is greater there than in either Paraná or the state of São Paulo.

Table 6 – The internal rate of return (IRR) for the eucalyptus reforestation projects including land costs. Values from November 1999

	Minas Gerais		Paraná		São Paulo	
	Industrial enterprise buys only roundwood from the first clear-cut	Industrial enterprise buys roundwood from the first and second clear-cuts	With donation of seedlings	Farmers buy seedlings	With donation of seedlings	Farmers buy seedlings
	MG3	MG4	PR3	PR4	SP3	SP4
IRR	20.12	21.74	7.72	7.13	9.99	9.35

Source: Néris (2001)

Tables 5 and 6 pointed out the importance of seedling donation to reforestation project profitability. When the cost of land is excluded from start-up costs, seedling donation increases the profitability of reforestation projects in the states of Paraná and São Paulo by 20.4% and 20.3% respectively. If the cost of land is included, seedling donation increases the IRR by only 8.3% and 6.8% in the same states (Table 6).

In Minas Gerais, when the cost of land is excluded, the donation of seedling and agricultural inputs increases IRR by 71.87% and 61.98% for project MG1 and MG2 respectively. When the cost of land is including, the donation of seedling and agricultural inputs increases IRR by 52.19% and 43.88% for projects MG3 and MG4 respectively (see Néris, 2001).

Table 7 shows the updated total costs (UTC) for the cases that excludes land cost.

Table 7 – Updated total cost (UTC) of eucalyptus reforestation projects (in R$/ha), with opportunity costs of from 6% to 20% per year excluding land costs excluded. Values from November 1999

Opportunity costs (%)	Minas Gerais		Paraná		São Paulo	
	Industrial enterprise buys only roundwood from the first clear-cut	Industrial enterprise buys roundwood from the first and second clear-cuts	With donation of seedlings	Farmers buy seedlings	With donation of seedlings	Farmers buy seedlings
	MG1	MG2	PR1	PR2	SP1	SP2
6	3,665.73	3,665.73	925.83	1,054.14	1,044.09	1,190.73
7	3,352.66	3,352.66	873.65	1,001.96	980.01	1,126.65
8	3,078.48	3,078.48	827.81	956.12	923.85	1,070.49
9	2,837.44	2,837.44	787.38	915.69	874.43	1,021.07
10	2,624.78	2,624.78	751.60	879.91	830.78	977.42
11	2,436.50	2,436.50	719.83	848.14	792.08	938.72
12	2,269.22	2,269.22	691.52	819.83	757.64	904.28
13	2,120.12	2,120.12	666.21	794.52	726.89	873.53
14	1,986.79	1,986.79	643.51	771.82	699.33	845.97
15	1,867.21	1,867.21	623.10	751.41	674.54	821.18
16	1,759.64	1,759.64	604.68	732.99	652.19	798.83
17	1,662.60	1,662.60	588.01	716.32	631.96	778.60
18	1,574.83	1,574.83	572.89	701.20	613.60	760.24
19	1,495.23	1,495.23	559.13	687.44	596.89	743.53
20	1,422.85	1,422.85	537.83	674.89	581.64	728.28

Source: Néris (2001)

According to Table 1, MG2 project is the most profitable reforestation project when the interest rate is 6% per year and when the present value is adopted for evaluating the projects. The UTC adds budgetary restrictions to the entrepreneur, who will refuse the MG2 project if he does not have R$3,665.73 available to invest (Table 7). The same reasoning applies for the other projects and discount rates. By including the land cost and assuming the 6% per year as the discount rate, the entrepreneur will need R$ 4,065.73 to implant the most profitable project of reforestation in the state of Minas Gerais (Table 8).

Table 8 – Updated total cost (UTC) of eucalyptus reforestation projects (in R$/ha), with opportunity costs of from 6% to 20% per year including land costs. Values from November 1999

Opportunity costs (%)	Minas Gerais		Paraná		São Paulo	
	Industrial enterprise buys only roundwood from the first clear-cut	Industrial enterprise buys roundwood from the first and second clear-cuts	With donation of seedlings	Farmers buy seedlings	With donation of seedlings	Farmers buy seedlings
	MG3	MG4	PR3	PR4	SP3	SP4
6	4,065.73	4,065.73	2,233.36	2,361.67	2,678.87	2,825.51
7	3,752.66	3,752.66	2,181.18	2,309.49	2,614.79	2,761.43
8	3,478.48	3,478.48	2,135.34	2,263.65	2,558.63	2,705.27
9	3,237.44	3,237.44	2,094.91	2,223.22	2,509.21	2,655.85
10	3,024.78	3,024.78	2,059.13	2,187.44	2,465.56	2,612.20
11	2,836.50	2,836.50	2,027.36	2,155.67	2,426.86	2,573.50
12	2,669.22	2,669.22	1,999.05	2,127.36	2,392.42	2,539.06
13	2,520.12	2,520.12	1,973.74	2,102.05	2,361.67	2,508.31
14	2,386.79	2,386.79	1,951.04	2,079.35	2,334.11	2,408.75
15	2,267.21	2,267.21	1,930.63	2,058.94	2,309.32	2,455.96
16	2,159.64	2,159.64	1,912.21	2,040.52	2,286.97	2,433.61
17	2,062.60	2,062.60	1,895.54	2,023.85	2,266.74	2,413.38
18	1,974.83	1,974.83	1,880.42	2,008.73	2,248.38	2,395.02
19	1,895.23	1,895.23	1,866.66	1,994.97	2,231.67	2,378.31
20	1,822.85	1,822.85	1,854.11	1,982.42	2,216.42	2,363.06

Source: Néris (2001).

The Simple Payback (SPB) period for both Paraná projects was 7 years at all discount rates if land costs are excluded (PR1and PR2). The Economic Payback (EPB) period for project PR2 was 14 years when the interest rate ranged from 15% to 18% per year. In other words, it would take the entrepreneur 14 years to recover his capital investment. If the interest rate is above 18% per year, there is no Economic Payback for project PR2. When including land costs in the start-up costs for both projects (PR3 and PR4), the SPB period is 14 years. For these same projects, the EPB period is 21 years when the interest rate is 7% per year, and there is no EPB for either project when the interest rates are 8% and above.

In the state of São Paulo, the SPB was 7 years at all considered opportunity costs. The EPB was also 7 years for both projects when excluding land costs (SP1 and SP2). If land costs are considered (SP3 and SP4), the EPB is 14 years when the interest rate is 6% per year, jumping to 21 years when the interest rate ranged from 8% to 9%. There is no EPB when the interest rate is 10% per year or above.

In Minas Gerais, the SPB was also 7 years when land costs are excluded (MG1 and MG2). If land costs are included as a project implementation cost (MG3 and MG4), the EPB period is 7 years when interest rates range from 6% to 19% per year, increasing to 14 years when the interest rate is 20% per year.

Table 9 shows the expected values of a hectare of land (EVL) for projects that exclude land costs from implementation costs. Projects that have an EVL that is less than the land's value are refused. In November 1999, the value of one hectare of reforestation land was R$ 1,634.78 in the state of São Paulo, R$ 1,307.53 in Paraná, and only R$ 400.00 in Minas Gerais.

Table 9 – Expected value of reforestation project land (EVL) with opportunity costs ranging from 6% to 20% per year (values, November 1999 R$/ha)

Opportunity costs (%)	Minas Gerais		Paraná		São Paulo	
	Industrial enterprise buys only roundwood from the first clear-cut	Industrial enterprise buys roundwood from the first and second clear-cuts	With donation of seedlings	Farmers buy seedlings	With donation of seedlings	Farmers buy seedlings
	MG1	MG2	PR1	PR2	SP1	SP2
6	3,222.32	4,127.79	1,888.88	1,707.09	3,326.18	3,118.43
7	2,660.92	3,399.75	1,516.67	1,347.50	2,720.63	2,527.30
8	2,237.60	2,851.52	1,237.78	1,077.67	2,266.90	2,083.90
9	1,906.37	2,423.42	1,021.16	867.74	1,914.44	1,739.10
10	1,639.70	2,079.66	848.18	699.82	1,632.94	1,463.39
11	1,420.06	1,797.46	706.97	562.52	1,403.11	1,238.02
12	1,235.80	1,561.63	589.63	448.24	1,212.08	1,050.49
13	1,078.85	1,361.65	490.70	351.71	1,050.96	892.12
14	943.48	1,190.00	406.25	269.19	913.38	756.74
15	825.47	1,041.15	333.41	197.90	794.68	639.81
16	721.66	910.95	270.04	135.78	691.34	537.90
17	629.64	796.22	214.48	81.24	600.70	448.42
18	547.52	694.47	165.44	33.03	520.65	369.33
19	473.83	603.73	121.91	-9.82	449.55	299.01
20	407.37	522.42	83.07	-48.09	386.08	236.18

Source: Néris (2001).

Evaluating using EVL criteria, all projects are economically viable when the interest rate is 7% per year. However, projects PR1 and PR2 are refused when the interest rate is greater than 7% per year; projects SP1 e SP2 are refused when the interest rate is greater than 9% per year; and all projects other than MG1 and MG2 are refused at the highest interest rate of 20% per year. Projects MG1 and MG2 are viable at all interest rates because the cost of land for reforestation purposes is very low in Minas Gerais, much less in than in São Paulo or Paraná.

The results shown above prove that seedling costs significantly influence the profitability indicators of eucalyptus-based reforestation

projects. Hence, forest programs based on seedling donations stimulate reforestation. The results from deterministic analysis also point out the role of land cost in influencing profitability indicators. Hence, seedling donation-based programs have the greatest impact when applied to land that has few other economic uses, in other words, planting free seedlings on relatively inexpensive land is the best way to insure project profitability.

Because of the lengthy seven year period between eucalyptus planting and harvest, an unusual amount of uncertainty and risk must be considered in project evaluation. This can be accomplished through use of the Monte Carlo Method.

5. Risk Analysis According to the Monte Carlo Method

By assuming the stochastic nature of eucalyptus-based reforestation project profitability indicators, explained by inherent crop characteristics, risk can be evaluated using the Monte Carlo method based Hertz Model (see: Noronha, 1988).[8]

The Monte Carlo Method, one of many risk analysis techniques, offers the investor a numeric estimate of project risk that can be used to estimate the likelihood of a specific reforestation project generating profit. It is an easy to use approach that employs likelihood to analyze risk (Noronha, 1988). In the next section we discuss our use of the Monte Carlo Method.

5.1 – Monte Carlo Method

According to Noronha (1988, p. 241), the Monte Carlo Method establishes the "likelihood distribution" of a profitability indicator

[8] Hertz, O.B. "Risk Analysis in Capital Investment.", **Harvard Business Review**, 42(1): 95-106, Jan./Feb., 1964.

(IRR, PV, for example) to serve entrepreneurial decision making. The Method simulates values for previously selected variables in order to calculate a specific profitability indicator. By repeating that process, the Monte Carlo Method generates a likelihood distribution for each profitability indicator.

The Monte Carlo Method follows three steps. First, a likelihood distribution is assumed for each relevant variable selected. According to Takitane (1988, p. 41), this distribution is based on the experience of the farmer, agricultural technician, scientific researcher, or decision maker. Subjective estimates of likelihood are commonly used when the distribution of each variable's variation interval is unknown. Second, random values are selected for each variable. These values take into account the likelihood distribution and are used to form a new cash flow. Third, profitability indicators (such as IRR, PV, B-C ratio) are calculated by using the new cash flows. That process is repeated until the likelihood distributions of each profitability indicator are obtained.

In this paper, random variables, such as the price of firewood, start-up costs (with or without seedling costs), and first year maintenance costs, are selected.[9] Due to the absence of information needed to determine likelihood distributions, triangular distributions are used. According to Takitane (1988, p. 42), a triangular distribution is defined by the most probable value or mode (m) and by the minimum (a) and maximum (b) values of the x-variable. In this paper, the mode is considered as being equal to the medium value of x, in other words, $L\{a \leq x \leq b\} = 1$.

ALEAXPRJ software, created by Azevedo Filho (1988),[10] was employed to create simulations. By using that software, one can classify variables according to their nature, i.e., exogenous[11] or endogenous, if they are defined externally or internally to the simulation

[9] See appendix 8 of Néris (2001).

[10] To obtain more explanations about this software, see Azevedo Filho, 1988. ALEAXPRJ – Sistema para Simulação e Análise Econômica de Projetos em condições de Risco: Manual do Usuário. USP/PCP/CIAGRI – 43 pages.

[11] The user can use five types of likelihood distribution for the exogenous variables: normal, triangular, entire (with two values), uniform and spike (constant value with likelihood of zero or one).

process. The economic time period of the project is another variable classification. Hence, variables can be classified as temporary (i.e., when they assume different values for each time period) or constant (when they have a unique value for all time periods).

5.2 - Results of estimated indicators – Monte Carlo analysis

A minimum opportunity cost of 6% was considered for risk analysis. This is equal to the least profitable local financial investment, i.e., the Brazilian savings account.[12] The simulation results are shown in separate tables for each state. Each table shows the mean, standard deviation, the limit value established for each estimate, the likelihood of values greater than the limit value, and the number of simulations that failed. The limit value for each estimate is equal to the value obtained in the earlier deterministic analysis of that project.

Table 10 shows the simulated values for reforestation conducted in the state of Paraná using Monte Carlo methodology. Looking at the column "mean," which shows the values of profitability indicators, it is possible to conclude that the reforestation projects are viable even in conditions of risk. However, the indicator values are inferior to those arrived at through deterministic analysis. Only updated total cost (UTC) is greater when calculated through risk analysis than through deterministic analysis.

[12] In this paper, only small-sized reforestation projects are taken into account. It may be assumed that they are managed by persons with little capital. Normally, these individuals keep their saving in saving accounts like other small investors.

Table 10 – Profitability indicators according to risk analysis of eucalyptus planting in the state of Paraná, considering 6% per year opportunity cost

Type of project	Indicator	Mean	Standard deviation	Limit value (LV)	L(I>LV)	Failed cases
With donation of seedling to farmers and excluding the land costs (PR1 project)	IRR	0.222	0.023	0.226	0.445	0
	PV	1293.516	179.518	1335.250	0.430	0
	B-C ratio	2.301	0.216	2.440	0.245	0
	SPB	7.000	0.000	7.000	0.000	0
	EPB	7.000	0.000	7.000	0.000	0
	UTC	999.777	55.900	925.830	0.915	0
With farmers buying seedling, but excluding the land costs (PR2 project)	IRR	0.184	0.020	0.188	0.415	0
	PV	1159.380	182.006	1204.940	0.405	0
	B-C ratio	2.032	0.196	2.140	0.320	0
	SPB	7.000	0.000	7.000	0.000	0
	EPB	7.000	0.000	7.000	0.000	0
	UTC	1131.691	70.321	1054.140	0.875	0
With donation of seedling to farmers and including the land costs (PR3 project)	IRR	0.079	0.015	0.077	0.495	0
	PV	391.548	272.844	410.340	0.485	0
	B-C ratio	1.190	0.150	1.180	0.505	0
	SPB	12.845	3.041	14.000	0.025	0
	EPB	19.382	3.216	21.000	0.000	14
	UTC	2270.374	309.506	2233.360	0.545	0
With farmers buying seedlings and including the land costs (PR4 project)	IRR	0.073	0.015	0.071	0.485	0
	PV	263.282	297.861	282.030	0.470	0
	B-C ratio	1.126	0.147	1.120	0.460	0
	SPB	13.615	2.736	14.000	0.050	0
	EPB	19.812	2.956	21.000	0.000	35
	UTC	2383.182	310.376	2361.670	0.540	0

Source: Néris (2001).

Present Value and Internal Rate of Return estimates of eucalyptus-based reforestation projects in the state of Minas Gerais are more profitable when arrived at using risk analysis (Table 11) rather than deterministic analysis, as opposed the results for Paraná. The UTC estimates from the risk analysis for projects in Minas Gerais are greater than the ones from deterministic analysis, demonstrating that farmers need more financial resources to invest in conditions of risk. MG3 was the only project that failed under risk conditions, and this occurred in

only one case when the project was evaluated from the perspective of EPB. The IRR for reforestation projects in Minas Gerais that included land cost ranged from 21% (project MG3) to 22.7% (MG4), with a standard deviation of 0.05 and 0.046 respectively.

Table 11 – Profitability indicators according to risk analysis of eucalyptus planting in the state of Minas Gerais, considering 6% per year opportunity cost

Type of project	Indicator	Mean	Standard deviation	Limit value (LV)	L(I>LV)	Failed cases
Industrial enterprise buys only roundwood from the first clear-cut, excluding land cost (MG1 project)	IRR	0.302	0.070	0.296	0.545	0
	PV	2231.409	892.469	2275.640	0.485	0
	B-C ratio	1.556	0.238	1.620	0.375	0
	SPB	7.000	0.000	7.000	0.000	0
	EPB	7.000	0.000	7.000	0.000	0
	UTC	4070.452	274.025	3665.730	0.940	0
Industrial enterprise buys roundwood from the first and second clear-cuts, excluding land cost (MG2 project)	IRR	0.325	0.053	0.309	0.600	0
	PV	3165.799	771.129	2913.580	0.595	0
	B-C ratio	1.781	0.209	1.790	0.480	0
	SPB	7.000	0.000	7.000	0.000	0
	EPB	7.000	0.000	7.000	0.000	0
	UTC	4086.471	252.744	3665.730	0.945	0
Industrial enterprise buys only roundwood from the first clear-cut, including land cost (MG3 project)	IRR	0.210	0.050	0.201	0.560	0
	PV	2037.868	800.378	1992.120	0.475	0
	B-C ratio	1.458	0.192	1.490	0.400	0
	SPB	7.000	0.000	7.000	0.000	0
	EPB	7.000	0.000	7.000	0.005	1
	UTC	4500.407	270.546	4065.730	0.955	0
Industrial enterprise buys roundwood from the first and second clear-cuts, including land cost (MG4 project)	IRR	0.227	0.046	0.217	0.570	0
	PV	2833.666	893.601	2631.24	0.580	0
	B-C ratio	1.638	0.212	1.650	0.465	0
	SPB	7.000	0.000	7.000	0.000	0
	EPB	7.105	0.853	7.000	0.015	0
	UTC	4484.142	272.542	4065.73	0.940	0

Source: Néris (2001).

According to Table 12, reforestation projects in the state of São Paulo retain their profitability even risk conditions. Generally, IRR and PV are similar in both risk and deterministic analyses. The least profitable

project (SP4 - farmers buy seedlings and land cost is included) shows an IRR equal to 9.4% with a standard deviation of 0.025. This is the same IRR and a smaller standard deviation than arrived at through deterministic analysis. However, payback times in risk analysis are greater than those arrived at through deterministic analysis.

Table 12 – Profitability indicators according to risk analysis of eucalyptus planting in the state of São Paulo, considering 6% per year opportunity cost

Type of project	Indicator	Mean	Standard deviation	Limit value (LV)	L(I>LV)	Failed cases
With donation of seedling to farmers and excluding the land costs (SP1 project)	IRR	0.298	0.054	0.302	0.480	0
	PV	2311.082	641.166	2347.770	0.475	0
	B-C ratio	3.088	0.597	3.250	0.375	0
	SPB	7.000	0.000	7.000	0.000	0
	EPB	7.105	0.000	7.000	0.015	0
	UTC	1116.219	77.835	1044.090	0.800	0
With farmers buying seedling, but excluding the land costs (SP2 project)	IRR	0.254	0.051	0.251	0.535	0
	PV	2219.724	648.149	2201.130	0.510	0
	B-C ratio	2.771	0.546	2.850	0.465	0
	SPB	7.000	0.495	7.000	0.000	0
	EPB	7.070	0.982	7.000	0.010	0
	UTC	1264.155	78.818	1190.730	0.780	0
With donation of seedling to farmers and including the land costs (SP3 project)	IRR	0.097	0.036	0.100	0.460	0
	PV	1122.910	2325.831	1193.860	0.500	0
	B-C ratio	1.406	0.392	1.450	0.450	0
	SPB	10.745	5.058	7.000	0.495	0
	EPB	15.686	5.777	14.000	0.377	9
	UTC	2866.390	3150.830	2678.870	0.665	0
With farmers buying seedlings and including the land costs (SP4 project)	IRR	0.094	0.025	0.093	0.490	0
	PV	1040.721	718.803	1047.220	0.500	0
	B-C ratio	1.370	0.276	1.370	0.475	0
	SPB	10.815	4.314	7.000	0.480	0
	EPB	15.816	4.991	14.000	0.416	15
	UTC	2990.697	405.579	2825.510	0.640	0

Source: Néris (2001)

By comparing the results shown in Tables 10 through 12 with the profitability indicators calculated for permanent and temporary tree crops and forestry in Table 13, it is possible to state that small eucalyptus-

based reforestation projects generally show a larger IRR and a shorter payback period than the other listed agricultural land-use alternatives.

Table 13 – Profitability indicators estimates for agricultural projects considering risk analysis but excluding land costs

Project	Internal Rate of Return	Simple Payback	Economic Payback
Orange tree plantation (productivity falling)	0.180	10.484	0.180
Orange tree plantation (stable productivity)	0.192	10.406	n.d.*
Rubber tree plantation	0.196	13.535	n.d.*
Rubber tree plantation	0.144	18.570	0.144
Centrolobium tomentosum tree plantation	0.169	25.000	25.000
(farmers buying seedlings)	0.222	18.655	25.000
Centrolobium tomentosum tree plantation	0.152	25.000	25.000
(farmers do not buy seedlings)	0.192	23.325	25.000
Balfourodendron riedelianum tree plantation	0.170	25.000	25.000
(farmers buying seedlings)	0.197	24.840	25.000
Balfourodendron riedelianum tree plantation			
(farmers do not buy seedlings)			
Araucaria Angustifolia tree plantation			
(farmers buying seedlings)			
Araucaria Angustifolia tree plantation			
(farmers do not buy seedlings)			

Source: Néris (2001)
* This data is not available

The results above point out that the donation of seedlings and agricultural inputs to farmers can strongly reduce their start-up costs and increase the profitability of their reforestation projects. Moreover, by avoiding the expense of seedling purchase, small and medium size farmers can better care for their plantations, thus increasing productivity, an important variable in determining the profitability of reforestation projects.

6. Conclusion

Seedling donations are commonly used to stimulate the owners

of small and medium size farms to plant forests. In this paper, we examine the effect of both seedling donation and seedling purchase on the profitability of eucalyptus-based reforestation projects. However, available information only permits that analysis for specific areas within the states of Minas Gerais, Paraná, and São Paulo where there has been an increase in the number of small-scale reforestation projects. These three states have different reforestation productivity, integration between farmers and wood-based industries, and subsidies for reforestation; however, their tree farm rotation systems are similar: a 21-year total cycle with three clear-cuts.

Both deterministic and risk analysis showed that small eucalyptus-based reforestation projects are economically viable. According to the Monte Carlo risk analysis technique, the internal rate of return (IRR) is about 7% in the state of Paraná and 9% in the state of São Paulo when it assumed that farmers buy seedling and include the land cost in start-up costs. In the state of Minas Gerais, IRR ranges from 21% to 23% when seedlings and other agricultural inputs are donated. The two percentage point interval between these two projects in Minas Gerais is determined by the buying scheme adopted between the wood-based enterprise and the farmer.

Analysis under deterministic conditions showed that seedling donation increases IRR by 8.3% and 6.8% in the states of Paraná and São Paulo respectively. In the state of Minas Gerais, donation of seedlings and agricultural inputs increases IRR by 52.19% and 43.88% (projects MG3 and MG4 respectively).

It can be pointed out that the donation of seedlings and agricultural inputs reduces reforestation costs; consequently, the farmers can make more money. However, programs that stimulate reforestation also need to assist in the creation of beneficial trading schemes. The difference in profitability found between Minas Gerais' reforestation projects and those of the other two states is partially explained by the more advantageous forest product trade chain found in Minas Gerais.

This highlights the importance of wood producers and wood-based industries working in an integrated manner. Government forest policies need to focus on that integration and associate with private enterprise to stimulate tree planting on small and medium size farms.

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