

*Full Length Research Paper*

# The latest research progress of forest economics and analysis: Based on the review and analysis of studies in the two international authoritative journals

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As a cross discipline, the study scope of the forest economics has expanded continuously. Based on the review and analysis of the study in the two international authoritative journals, "Journal of Forest Economics" and "Forest Policy and Economics" from 2010 to 2014, this paper discussed the latest research progress of forest economics and the main contents of the study in order to provide a reference for the construction of the disciplinary system of the forest economics and its development. By using the method of cluster and variance analyses, the study points out that although the research of forest economic scope is expanding constantly, the contents of the research of forest economics mainly focus on the study of forest resources utilization and its benefits, forest management and economic analysis, as well as timber production and its market research. The paper suggests that construction of the disciplinary system of the forest economics in the world also should begin with the core contents and the latest research progress of forest economics, build a scientific system of theories and methods for it step by step, keep pace with the times, and the research contents should be renewed and improved constantly.

**Key words:** Cluster analysis, discipline system, forest economics, forest management, research progress.

## INTRODUCTION

Forest economics is a cross-discipline subject, which studies the mutual effect of social, economic and forest ecosystems, how the latest research results of economics is applied into the development of social, economic and forest ecosystems, and how the research is providing theoretical direction and practical reference to its theories

and practices (Kant et al., 2013). In recent years, the research scope of forest economics has expanded unceasingly. However, the recent advances and the contents of the research are unknown to us. Based on the review and analysis of the two international authoritative journals, Journal of Forest Economics and

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Forest Policy and Economics from 2010 to 2014, this paper discusses the research development and main contents of forest economics, thus providing a reference to the construction and development of the system of forest economics, as well as the reform of forest economic management in the world.

## RESEARCH PROGRESS

Since Faustmann model was put forward in 1849, the research of the forest economy had been gradually formed and had attracted great importance from then on, so it was with the forest economics (Faustmann et al., 1849). Started from the research of the Faustmann optimal harvest model, the forest economics research scope has largely expanded from the study of the optimal harvest model under the economic net income maximization to the optimal model including ecological benefits, social benefits, tax and fee system and the international trade and other factors with the macroeconomic investment theory brought in (Xie et al., 2007). According to the statistics, there are more than 500 articles about Faustmann model since it was first proposed (Kant et al., 2013). However, based on many assumptions and inferences, the Faustmann model is simply a part, but not the whole of forest economic research. Forest economy is a cross-discipline subject, which involves society, economy, forestry ecosystem, etc. It needs to establish a scientific discipline system that could be able to cover the relevant knowledge, and to go through the constant competition, refute, rational criticism, discussion of the theoretical knowledge and practice of the verification process. In recent years, rapid development of forest economy has been achieved. The scope of the forest economics has been gradually expanded and the research in some extent is now being developed especially after 2003 (Schlüter and von Detten, 2011), with the introduction of the post-Keynesian consumer theory, behavioral economics, social choice theory, nonlinear programming, and discounting theory and methods.

In 1974, the economist P. A. Samuelson gave a speech named the sustainable forestry economic harvest. In his speech, he pointed out that the policy target of traditional forest economic management, to some extent, can be defined as a means of maintaining sustainable timber production or largest timber production (Samuelson, 1995). Then he also indicated that this definition was questioned by some economists. He suggested that when we do research on the largest timber production, we should take both "internal" and "external", land rent, interest rate, inflation rate, income, taxation, labor force, land-use change, etc., into consideration (Hartman, 1976).

Forests provide not only the economic value of the products, such as timber, fruit, rubber, etc., but also

provide the value of the non-wood products, noted by Peters et al. (1989) in a research of the evaluation of rain forest. These values should also give high priority even in choosing the optimal rotation period (Peters et al., 1989).

Park et al. (1998) when doing the research on economic problems of the temperate and tropical forest land use, also pointed out that the value of forest carbon sink, species conservation, etc., should be given high priority when determining the value of the forest land.

On the 23rd International Forestry Research Organization Conference in 2010, when Kant et al. (2003, 2013a, 2013b) were giving a summary on the research front of forest economy, they stated that the new institutional economics, behavioral economics, public choice theory, related theories and methods of income, in recent years, have been introduced into the study of forest economics, which further expanded the research scope of forest economy. In the later research summary after the conference, they discussed the latest research theories and methods with personnel concerned and made a sum up of the main research contents and cutting edges at present.

The main research contents are as follows:

- (1) Forest management decision making research on multi-objective utilization and forest ecosystem management (Arthur, 1994).
- (2) An exploration of the connotation and definition of forest economy. They hold the opinion that economics is a discipline that studies and explains the relationship between human beings and the relationship triggered by different systems.
- (3) The research on the dynamical problems caused by the non-linear relationship between forest ecosystem and economic system.
- (4) The research on aesthetics, spirits, and cultural value of the forestry. Though all of these are not so important in ecosystem services and their value was mistakenly evaluated on the market; the public choice theory should be adopted for valuation, which is also an important part of forest economics field study.
- (5) Urbanization changes people's values, so the social needs of forest recreation, ecosystem services, and environment friendly forest management activities have also increased. These needs not only change the research contents of forest economics, but also becomes an important part of it.
- (6) The application of neoinstitutional economics in forest economic research. The main research should be focused on the exploration of the relationship between forestry administrative structure and resource users by related theory of neoinstitutional economics, especially on the study of application to watershed harnessing.
- (7) The research of forestry long-term production management and decision-making. It has been the contents worth studying that the uncertainty of climate change has led to different expectations from the forestry

production operators for forestry revenue, and in turn caused many management and decision-making problems.

(8) The research of the compensation and payment framework between the society and ecosystem, especially the compensation and payment framework that is based on the social economy and social system.

(9) The research of the market mechanism of the forest ecosystem services, especially the research that could be applied to the spontaneous market mechanism formed by both the sellers and buyers who has the willingness to pay for the forest ecosystem services.

(10) The research of the design for forest ecosystem services payment. High priority should be given to the cases of the intersystem payment design.

(11) The research of the forest carbon sinks and forest carbon sinks to offset the carbon emissions. Forest carbon sinks is not only an environmental problem but also a basic issue of human rights. Studies must be embarked on to solve this problem; everyone should have the same right of carbon emission (Wang and Wilson, 2007).

In a word, since forest economics made its debut, with the introduction of different schools of economic theories and methods, the contents and scope of forest economy research have gradually expanded and forest economics finally came into being (Schlüter and von Detten, 2011). This paper mainly collected the papers in the Journal of Forest Economics and Forest Policy and Economics and did research on the latest research development and contents by the means of cluster analysis and analysis of variance, and also hope that this study can be used as a reference to the development of the discipline of forest economics.

## RESEARCH METHODS

This paper analyzes the latest research development and contents by the means of cluster analysis and variance analysis.

Cluster analysis, a multivariate statistical technique to classify samples or indicators, is consisted of hierarchical clustering and K-Means clustering (quick clustering). Hierarchical clustering attempts to identify relatively homogeneous groups of cases (or variables) based on selected characteristics, using an algorithm that starts with each case (or variable) in a separate cluster and combines clusters until only one is left. K-Means clustering can handle large numbers of cases based on selected characteristics into k homogeneous groups. Its clustering is faster compared with the hierarchical clustering. Specifically, in this study hierarchical clustering was mainly used, and Between-groups Linkage was used in cluster method. When measuring the distance of cases (or variables), the Squared Euclidean Distance was also used.

ANOVA, short for analysis of variance, is a statistical technique for studying the observed variability characteristics of variables and independent variables. The variability is reflected through the significance testing of the mean difference of two or more samples. In the research, the differences between different research contents were analyzed to summarize the up-to-date research trends and the main research contents of forest economics. Specifically, ANOVA was used showing that different clusters do differ and gives

information on each variable's contribution to the separation of the groups.

## Research data

A total of 685 research articles and critiques in the two main international authoritative journals from 2010 to 2014 were collected to make a base for this study.

As the recognized authoritative academic forest economics and policies journals in the world, Journal of Forest Economics and Forest Policy and Economics mainly publish stringent standards of research articles of forestry economy and policy reviewed anonymously by peers. Social sciences and humanities related research papers that would have an impact on forest economy can also be published in the two journals; but these papers must have specific theories, conception and methods. So far the two journals are indexed in SCI, SSCI, EI, etc. In 2014, the impact factor of Journal of Forest Economics is 1.143 and 1.488 for five consecutive years (Journal of Forest Economics, 2015). While the impact factor of Forest Policy and Economics is 1.856 and 2.129 for five consecutive years (Forest Policy and Economics, 2015).

First of all, main research contents of the 685 articles of the two journals in 2010 to 2014 were extracted through "look up" and "select" tool in EXCEL of Microsoft Office and classified into groups. Secondly, the number of articles of different groups was counted, respectively, so was the percentage of total articles. The top 10 studied contents of articles in the two journals were sum up and the rest of the articles were all put into the group of "others". The statistics of the articles published in the Journal of Forest Economics and Forest Policy and Economics in 2010-2014 is shown in Tables 1 and 2.

## RESULTS

According to the statistics in Tables 1 and 2, Table 3 shows the top 10 study contents between 2010 and 2014 on the basis of the percentage of the total number of paper for the different study contents.

As is shown in Table 3, carbon sequestration evaluation stands first with 12.86%; 11.43% of the total number of papers, which ranks second, study the forest management and economic analysis; fewer papers cover the content of forest recreation evaluation with 5.71%.

Cluster analysis has been used in the study of the 10 research contents for finding out the latest research progress and the main research contents. Firstly, the ten research contents can be clustered into 4 groups by quick clustering. This procedure attempts to identify relatively homogeneous groups of research contents based on the ranks and the percentage of the total number of papers; the statistics of initial cluster centers for 4 clusters are shown in Table 4. Here, the method is iterated and classified, convergence criterion is 0, maximum iterations is 10, and the Euclidean distance between the case and the cluster center used to classify the case. The iteration history of quick cluster is shown in Table 5. Secondly, under the hierarchical clustering, the tree diagram of hierarchical clustering is as shown in Figure 1.

It was clearly observed that it can be divided into 4 groups by systematic cluster analysis in the top 10

**Table 1.** The statistics of the articles published on the Journal of Forest Economics in 2010-2014 (in descending order).

S/N	Main research contents	Number of papers	Percentage of the total number of papers
1	other	36	25.71
2	carbon sequestration evaluation	18	12.86
3	forest management and economic analysis	16	11.43
4	Forest owners 'conservation benefit	12	8.57
5	optimal selective logging and its cost	11	7.86
6	the energy use of forest	10	7.14
7	timber production analysis	10	7.14
8	forest recreation evaluation	8	5.71
9	private forest	7	5
10	optimal forest harvest age	7	5
11	climate change affection	5	3.57
	total	140	100

Source: Journal of Forest Economics (2015).

**Table 2.** The statistics of the articles published on the Forest Policy and Economics in 2010-2014 (in descending order).

S/N	Main research contents	Number of papers	Percentage of the total number of papers
1	other	291	53.39
2	wood product and market	40	7.34
3	public and private forest landowners management	35	6.42
4	community forest management	34	6.24
5	forest ecosystem service management	24	4.4
6	forest-related conflicts	23	4.22
7	participatory forest management	23	4.22
8	conservation of forestry resources	20	3.67
9	carbon sequestration and CO <sub>2</sub> reduction management	20	3.67
10	biodiversity conservation	18	3.3
11	energy use production	17	3.12
	total	545	100.00

Source: Forest Policy and Economics (2015).

**Table 3.** The top ten research contents from 2010 to 2014.

Ranks	Contents	Number of papers	Percentage of the total number of papers	The journal sources
1	carbon sequestration evaluation	18	12.86	1
2	forest management and economic analysis	16	11.43	1
3	forest owners' conservation benefit	12	8.57	1
4	optimal selective logging and its cost	11	7.86	1
5	wood product and market	40	7.34	2
6	the energy use of forest	10	7.14	1
7	timber production analysis	10	7.14	1
8	public and private forest landowners management	35	6.42	2
9	community forest management	34	6.24	2
10	forest recreation evaluation	8	5.71	1

1: Journal of Forest Economics; 2: Forest Policy and Economics.

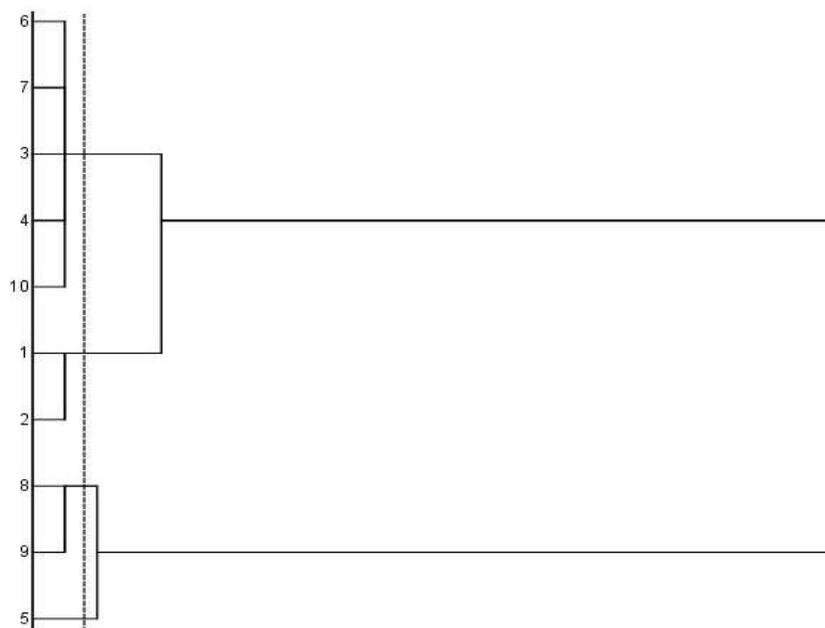
**Table 4.** Initial cluster centers.

Items	Cluster			
	1	2	3	4
Number of papers	34	16	40	8
The percentage of the total number of papers	6.24	11.43	7.34	5.71
Ranks	9	2	5	10

**Table 5.** Iteration history<sup>a</sup>.

Iteration	Change in cluster centers			
	1	2	3	4
1	0.515	0.321	8.88E-016	2.302
2	0.000	1.622	0.000	0.615
3	0.000	0.000	0.000	0.000

<sup>a</sup> Convergence achieved due to no or small change in cluster centers. The maximum absolute coordinate change for any center is 0.000. The current iteration is 3. The minimum distance between initial centers is 6.100.



**Figure 1.** Research contents clustering figure of forest economics. It can be divided into 4 groups in the top 10 research contents. That is the first group (6, 7, 3, 4, 10), the second group (1,2), the third group (8,9) and the fourth group (5). 1=carbon sequestration evaluation; 2=forest management and economic analysis; 3= forest owners' conservation benefit; 4= optimal selective logging and its cost; 5= wood product and market; 6=the energy use of forest; 7= timber production analysis; 8= public and private forest landowners management; 9=community forest management; 10=forest recreation evaluation.

research contents from Figure 1.

First group: {6,7,3,4,10}

Second group: {1,2}

Third group: {8,9}

Fourth group: {5}

**Table 6.** ANOVA's Table of cluster analysis.

Items		Sum of squares	df	Mean square	F	Sig.
Paper	Between groups	27996.042	3	9332.014	13129.054	0.000
	Within groups	135.050	190	0.711	-	-
	Total	28131.093	193	-	-	-
The percentage of the total number of paper	Between groups	819.079	3	273.026	852.749	0.000
	Within groups	60.833	190	0.320	-	-
	Total	879.911	193	-	-	-

**Table 7.** Test of homogeneity of variances.

Items	Levene statistics	df1	df2	Sig.
Paper	65.036	3	190	0.000
The percentage of the total number of paper	92.940	3	190	0.000

Specifically, the four groups are as follows:

(1) The first group: The energy use of forest, timber production analysis, forest owners' conservation benefit, optimal selective logging and its cost, and forest recreation evaluation, and can be summarized as the research of forest utilization.

(2) The second group: Carbon sequestration evaluation, forest management and economic analysis, and can be summarized as the research of forest management and economic analysis.

(3) The third group: Public and private forest landowners management, community forest management, and can be summarized as the research of public forest, private forest and forest management.

(4) The fourth group: Wood product and market, and can be summarized as the research of wood product and market.

To further unveil the differences among the four groups, variance analysis has been used in the study. The ANOVA's Table is shown in Table 6.

As is shown in the Table 6, the significant differences of the four clustering results show statistical analysis. For the articles published on the two journals from 2010 to 2014, the F-value is 13129.054 and significance level is 0. While for the percentage of the total number of paper, the F-value is 852.749 and significance level is 0. The significance levels of both are less than 0. Therefore, the significant differences of the four clustering results show the clustering results is rational and of statistical significance.

One-Way ANOVA was also used to find out the discrepancy in different groups of clustering results. When equal variances were assumed, the Least Significant Difference was chosen; when the equal

variances were not assumed, the Tamhane was chosen. The results are shown in Table 7. From Table 7, it can be clearly seen that test of homogeneity of variances shows the clustering results of the four groups is unequal with the variance of articles and the percentage of the total number of papers is 65.036 and 92.940, respectively, which also means the variances are not assumed. Therefore, we use the method of Tamhane to analyze the differences of the clustering results of the four groups. The final analysis is shown in Table 8.

It can be seen from Table 8 that the standard error of groups 2 and 3 is 0.130; the significance level is 0.996, higher than 0.05. It means that though the cluster result of the four groups is rational, groups 2 and 3 should be integrated as one group. So we put forest management and economic analysis and management of public and private forest landowners, community forest management together and name it as forest management and economic analysis. Then the new classification should be the group of the study of the forest management and economic analysis, management of public and private forest landowners and community forest management. By the means of cluster analysis and variance analysis, the latest research development and contents of forest economics is the study of the benefits of forests, the forest management, the economic analysis of forests, and the timber production and marketing. All the statistics analysis and results also show that this conclusion is rational and of statistical significance. Though there are differences between the research development and the research contents, they are the representative research direction for forest economics.

## DISCUSSION

The research of the forest economy has made great

Table 8. Multiple comparisons.

Dependent variable	Between groups	Mean difference	Std. Error	Sig.	95% Confidence interval			
					Lower bound	Upper bound		
Paper	1	2	6.686*	0.187	0.000	6.320	7.050	
		3	-22.941*	0.197	0.000	-23.330	-22.550	
		4	-17.448*	0.177	0.000	-17.800	-17.100	
	2	1	-6.686*	0.187	0.000	-7.050	-6.320	
		3	-29.627*	0.178	0.000	-29.980	-29.280	
		4	-24.135*	0.156	0.000	-24.440	-23.830	
	LSD	3	1	22.941*	0.197	0.000	22.550	23.330
			2	29.627*	0.178	0.000	29.280	29.980
			4	5.493*	0.168	0.000	5.160	5.820
	4	1	17.448*	0.177	0.000	17.100	17.800	
		2	24.135*	0.156	0.000	23.830	24.440	
		3	-5.493*	0.168	0.000	-5.820	-5.160	
	Tamhane	1	2	6.686*	0.251	0.000	6.010	7.360
			3	-22.941*	0.174	0.000	-23.430	-22.450
			4	-17.448*	0.184	0.000	-17.960	-16.940
		2	1	-6.686*	0.251	0.000	-7.360	-6.010
			3	-29.627*	0.181	0.000	-30.120	-29.130
			4	-24.135*	0.191	0.000	-24.650	-23.610
		3	1	22.941*	0.174	0.000	22.450	23.430
			2	29.627*	0.181	0.000	29.130	30.120
			4	5.493*	0.061	0.000	5.330	5.660
		4	1	17.448*	0.184	0.000	16.940	17.960
			2	24.135*	0.191	0.000	23.610	24.650
			3	-5.493*	0.061	0.000	-5.660	-5.330
LSD	1	2	4.780*	0.125	0.000	4.530	5.030	
		3	4.847*	0.132	0.000	4.590	5.110	
		4	5.856*	0.119	0.000	5.620	6.090	
	2	1	-4.780*	0.125	0.000	-5.030	-4.530	
		3	0.067	0.120	0.573	-0.170	0.300	
		4	1.076*	0.104	0.000	0.870	1.280	
	3	1	-4.847*	0.132	0.000	-5.110	-4.590	
		2	-0.067	0.120	0.573	-0.300	0.170	
		4	1.009*	0.112	0.000	0.790	1.230	
4	1	-5.856*	0.119	0.000	-6.090	-5.620		
	2	-1.076*	0.104	0.000	-1.280	-0.870		
	3	-1.009*	0.112	0.000	-1.230	-0.790		
Tamhane	1	2	4.780*	0.180	0.000	4.300	5.260	
		3	4.847*	0.124	0.000	4.500	5.190	
Percentage of the total number of paper	LSD	3	1	-4.847*	0.132	0.000	-5.110	-4.590
			2	-0.067	0.120	0.573	-0.300	0.170
			4	1.009*	0.112	0.000	0.790	1.230
	4	1	-5.856*	0.119	0.000	-6.090	-5.620	
		2	-1.076*	0.104	0.000	-1.280	-0.870	
		3	-1.009*	0.112	0.000	-1.230	-0.790	
Tamhane	1	2	4.780*	0.180	0.000	4.300	5.260	
		3	4.847*	0.124	0.000	4.500	5.190	

Table 8. Contd.

	4	5.856*	0.125	0.000	5.510	6.200
	1	-4.780*	0.180	0.000	-5.260	-4.300
2	3	0.067	0.130	0.996	-0.290	0.420
	4	1.076*	0.130	0.000	0.720	1.430
	1	-4.847*	0.124	0.000	-5.190	-4.500
3	2	-0.067	0.130	0.996	-0.420	0.290
	4	1.009*	0.011	0.000	0.980	1.040
	1	-5.856*	0.125	0.000	-6.200	-5.510
4	2	-1.076*	0.130	0.000	-1.430	-0.720
	3	-1.009*	0.011	0.000	-1.040	-0.980

\*The mean difference is significant at the 0.05 level.

progress in term of the scope since Faustmann model was put forward in 1849 (Deegen and Seegers, 2011). However, seen from the research results, the latest progress and research contents focus on the studies of the utilization and returns of forests, the forest management, forest economic analysis, timber production, and timber market. Though the research depends mainly on the articles published on the two international authoritative journals in 2010 to 2014, and it may come to a situation that the contracted contents could not exactly or absolutely reflect the true and whole contents of these articles, or a situation that the research may have done a rough classification, the research results will be greatly helpful and have some reference meaning to such relative studies on forest economy.

With the introduction of the new schools of economic theories and the new technical means, the research contents of forest economy expand unceasingly. All of these have become a trend for forestry research. Besides, the study of new problems and application of multi-disciplines have also become the research directions for forest economy. Hence, it is of great importance for the building of theoretical system of forest economics that forest economic research should not only pay attention to the application of new theories and multiple disciplines, but also should give high priority to the new techniques in solving economic problems of forestry.

Research of the forest economy has a long history (Liu et al., 2008). From the study of wood cutting the reform of forestry rights and the forestry output value calculation to the study of the evaluation of forest ecosystem services at the moment, the world's forest economic researches have always been influenced by the different government's policies and strongly linked with the different government's policies in different periods (Tian, 2013; Zhang, 2014). On the one hand, this will be conducive to solve the practical problems in different developing periods in different countries; on the other

hand, this will be against the shaping and development of the theoretical system of forest economy. Therefore, it is imminent to build the theoretical system of forest economics based on the research problems in this field.

## Conclusions

It can be seen from the related research reviewed and the analysis of cluster and variance on the Journal of Forest Economics and Forest Policy and Economics that forest economics is an integration of sciences with continuously expanded range of study, which mainly adopts multidisciplinary and interdisciplinary approach to doing research on related economic problems. However, though the scope of research expanded so much, the latest development of the research and the research contents mainly focus on the studies of the utilization and returns of forests, the forest management, forest economic analysis, timber production and timber market. The building of the discipline of forest economics and the research of forest economics in the world should also embark on these issues and build a scientific system of theories and step by step methods.

In addition to the traditional subjects of forest economy, behavioral economics, complex and multiple equilibria, institutional economics, organizational economics, welfare economics and other theories which had not been studied and responses introduced in the research of forest economics, new theories and methods should also be taken into consideration when studying the new forest economic problems. These researches should not be constrained by being guided with different countries' policies in different periods. It should be kept in pace with the research contents and should be renewed and improved constantly worldwide. That is, it should also be stressed when building the discipline of forest economics in the world and the system of theories and methods.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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