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Unveiling the Economic Dynamics of Rice (*Oryza sativa* l.) Cultivation: An Experimental Study of Thanjavur District, Tamil Nadu, India

Yekula Deepak [a*], A. Renukadevi [b], S. Porpavai [c], K. Lakshmi Harika [a] and M. Sai Venkata Ravi Teja [d]

[a] Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, India.
[b] Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, India.
[c] Agricultural Research Station, Kattuthottam, Thanjavur, India.
[d] Department of Crop Physiology, University of Agricultural Sciences, GKVK, Bengaluru, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment on rice treatments to improve soil fertility and sustainable crop productivity was conducted at Agricultural Research Station, Thanjavur district, Tamil Nadu, India during the *rabi* season, 2021-2022 with an objective to assess the economic dynamics of rice crop in combination to green manure crops. The experiment consists of ten treatments of rice which were sown on 9th

**Corresponding author: E-mail: deepakyekula293@gmail.com;*

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September 2021 after harvesting of kharif crop in sandy loam soils. The results revealed that incorporating green manure crops along with rice yielded higher paddy output compared to the traditional rice-only practice. The highest test weight (24.1 g) was recorded under the treatment T_3-Rice+Dhaincha (5:1) which was statistically on par with T_4-Rice+Dhaincha (10:1). The Harvest index recorded highest (0.45) for the treatments T_3-Rice+Dhaincha (5:1) and T_8-Rice (Co 52). The economics of the experiment were worked and the cost of cultivation (Rs. 51500), gross income (Rs. 123487), net income (Rs. 71987), and benefit-cost ratio (2.40) were recorded highest in T_3-Rice+Dhaincha (5:1) variety. Additionally, the results unveiled a substantial correlation between grain yield and economic indicators. Notably, grain yield demonstrated a significant association, reaching a significance level of 95%, with both gross income and net income. Furthermore, an impressive positive correlation, significant at the 99% level, was identified between grain yield and two essential yield traits: test weight and harvest index. These findings underscore the potential of incorporating green manure crops in rice farming to enhance soil fertility, boost crop productivity, and ensure economic viability, thereby promoting sustainable agricultural practices.

Keywords: Rice; economics; harvest index; grain yield and straw yield.

1. INTRODUCTION

Rice is not just a staple food in India; it is deeply ingrained in the cultural, social, and economic fabric of the nation. As one of the largest producers and consumers of rice globally, India's agricultural landscape revolves around this essential crop [1]. Understanding the economics of rice cultivation in India is crucial for comprehending the complexities of the agricultural sector and the broader implications on the national economy [2]. The economics of rice crops in India encompasses a wide range of factors, including production costs, market dynamics, trade policies, government interventions, and the socio-economic impact on farming communities [3]. With diverse agro-climatic regions, varying farming practices, and a multitude of stakeholders involved, analyzing the economic aspects of rice cultivation in India presents a compelling and multi-dimensional narrative [4].

The economics of rice crops in the Thanjavur district of Tamil Nadu, India, presents a fascinating study of the economic dynamics and implications of rice cultivation in a region known as the "Rice Bowl of Tamil Nadu [5-7]." With its fertile soil, favorable climatic conditions, and rich agricultural heritage, the Thanjavur district holds a prominent position in the cultivation of rice, making it an ideal case for examining the economic aspects of this vital crop. Rice cultivation in the Thanjavur district goes beyond mere agricultural production—it significantly influences the local economy, livelihoods of farmers, and the overall socio-economic landscape of the region [8]. Understanding the economics of rice crop in this specific district involves analyzing a range of factors, including production costs, market trends, government policies, yield variations, and income generation [9].

One crucial aspect of rice crop economics in the Thanjavur district is assessing the productivity and efficiency of rice cultivation. Parameters such as grain yield, test weight, straw yield, and harvest index play a pivotal role in evaluating the economic viability and profitability of rice farming practices. By understanding the relationships among these variables, farmers can optimize their agricultural techniques and resource allocation to maximize yields and economic returns. The economic impact of rice cultivation extends beyond the farm level. Rice serves as a crucial component of the district's food security and contributes to the state's overall rice production [10]. The market dynamics, including price fluctuations, supply and demand trends, and trade patterns, affect the profitability of rice cultivation and shape the economic prospects of farmers in the Thanjavur district.

Costs of cultivation and gross income are vital economic indicators in rice crop economics. Analyzing the expenses associated with land preparation, seed selection, fertilizers, labor, and machinery provides insights into the financial aspects of rice cultivation [11]. Moreover, assessing the revenue generated through the sale of harvested rice grains and the value-added products derived from the crop contributes to understanding the economic benefits and potential income streams for farmers [12].

Furthermore, it is essential to evaluate the net income and benefit-cost ratio to gauge the profitability and efficiency of rice cultivation in the Thanjavur district. Net income represents the surplus revenue after deducting the production costs, providing a measure of the financial gains derived from rice cultivation. The benefit-cost ratio, on the other hand, assesses the economic viability of rice farming by comparing the benefits accrued to the costs incurred.

The economics of rice crop encompasses a multitude of factors that influence its profitability and sustainability [13]. From test weight and grain yield to harvest index and net income, understanding these economic indicators is vital for farmers, policymakers, and researchers seeking to optimize rice cultivation practices and ensure a thriving agricultural sector. Understanding these economic indicators is essential for optimizing rice cultivation practices, maximizing profitability, and ensuring the sustainability of the agricultural sector. By focusing on factors such as test weight, grain yield, straw yield, harvest index, gross income, cost of cultivation, net income, and benefit-cost ratio, stakeholders can develop strategies to enhance economic outcomes and promote the long-term success of rice crop cultivation [14]. Although majority of the researchers established the relationship between soil health and crops, only a few quoted about economical traits of crops in relation to their sustainability. By keeping the above factors in view, the present study is proposed in rice crop grown in Thanjavur district, Tamil Nadu to assess economic dynamics in relation to crop yields with the following objectives.

1) To assess the economic dynamics of rice crop regarding yield traits
2) To analyze the impact of yield traits on economics of rice crop using correlation and regression analysis

2. MATERIALS AND METHODS

2.1 Experimental Site

The current experiment was conducted in ten distinct treatments (refer to Table 1), at Agricultural Research Station, Thanjavur, Tamil Nadu, India, during the 2021-2022 period. The geographical coordinates of the research site were recorded as 10°45' North latitude, 79° East longitude, and an elevation of 50 meters above mean sea level. The study aimed to examine the economic parameters of rice crop. The experimental design employed a Randomized Block Design with ten replicated treatments. Each treatment was replicated thrice. Each plot occupied an area of 40 square meters.

Table 1. Treatment details of the experiment

Treatments	***Rabi***
T_1	Rice (ADT 46)
T_2	Rice (ADT 46)
T_3	Rice+dhaincha (5:1) (ADT 46)
T_4	Rice+dhaincha (10:1) (ADT 46)
T_5	Rice (ADT 46)
T_6	Rice (Bio fortified-CR Dhan45)
T_7	Rice (ADT 46)
T_8	Rice (Co 52)
T_9	Rice (Seeraga samba)
T_{10}	Rice (Navara)

2.2 Recorded Traits

2.2.1 Test weight

Thousand grains were counted, weighed and represented as 1000 grain weight in grams from a random sample of the net plot yield for each treatment.

2.2.2 Grain yield

The crop was harvested from each net plot and the grain yield was meticulously recorded and computed by multiplying net plot size and expressed in q ha^{-1}(or) kg ha^{-1}.

2.2.3 Straw yield

Straw from each treatment's net plot was sun-dried until it reached a uniform weight. The straw from the 10 selected hills was added to the net plot yields before expressing the total straw yield in kg ha^{-1}.

2.2.4 Harvest index

The harvest index is the proportion of grain yield divided by total biological yield (grain + straw). Yoshida *et al.* [15] established the formula for calculating it.

Harvest index (%) = Grain yield (kg ha-1) / Grain + Straw yield (kg ha-1) × 100

2.2.5 Economics of rice cultivation

The following equations were used to calculate the economics of rice farming.

GMR = Yield x Selling price
NMR = GMR - COC

Benefit cost ratio = Gross returns (Rs.) / Cost of cultivation (Rs.)

where,

Gross Monetary Return (GMR)
Net Monetary Return (NMR)
Benefit Cost Ratio (B:C)
Cost of Cultivation (COC)

2.3 Statistical Analysis

For data analysis, the statistical method of analysis of variance (ANOVA) was employed using the AGRES software, specifically the Data Entry Module for Agres Statistical software version 3.01 developed by Pascal Intl. Software Solutions in 1994. To determine the significance of differences between mean values, the least significant differences (LSD) test was utilized at a 5 percent probability level, following the recommendation of Gomez and Gomez [16]. Critical differences were calculated at the 5 percent significance level if significant differences were observed in the treatment groups based on the F-test. Principal Component Analysis and Pearson correlation were conducted using IBM SPSS version 22 software for the computation of the Soil Quality Index. The aforementioned statistical techniques were utilized to thoroughly analyze the collected data while ensuring statistical accuracy and integrity.

3. RESULTS AND DISCUSSION

The results of grain and straw yield of rice crop during *rabi* season are presented in Table 2. Test weight was between 20.6 to 24.1 g during the *rabi* season with a mean of 22.1 g. Highest (24.1 g) test weight was recorded in the treatment T_3-Rice (ADT 46) +Dhaincha (5:1) which was on par with T_4-Rice (ADT 46) +Dhaincha(10:1) and the lowest (20.6 g) was recorded in the treatment T_{10}-Rice (Navara). Significant differences were observed between the treatments. The variations in the genetic make-up of the varieties likely accounted for the variation in test weight among them. Also, the nutrients applied to the crop might have resulted in the accumulation of more test weight [17].

The data showed that the value of grain yield ranged between 2322 to 6672 kg ha^{-1} with a mean of 5041 kg ha^{-1}. A significantly higher (6672 kg ha^{-1}) grain yield was recorded in the treatment T_3-Rice (ADT 46) +Dhaincha (5:1) which was on par with the treatments T_4 and T_8 and the lower (2322 kg ha^{-1}) was observed in the treatment T_{10}-Rice (Navara). This might be associated with higher tillering capacity and it contains more grains per panicle compared to other varieties under rice cultivation [18].

The values of straw yield ranged between 3592 to 8219 kg ha^{-1} with a mean of 6638 kg ha^{-1}. A significantly higher (8219 kg ha^{-1}) straw yield was observed in the treatment T_3-Rice (ADT 46) +Dhaincha (5:1) which was on par with the treatment T_4 and the lower (3592 kg ha^{-1}) straw yield was observed under the treatment T_{10}-Rice (Navara). The better plant growth with higher dry matter production might be the cause for the higher straw yield of mentioned varieties [19]. According to Kusutani *et al.* [20] a crop's output of straw is directly related to its vegetative development, including plant height, tiller counts, number of leaves, and ultimate stand. The increase in the grain and straw yield of ADT 46 is related to higher tiller and dry matter production which resulted in superior yield attributes and yield. This effect is similar to the findings of Govindan and Grace [21].

It was revealed that the data showed that the values of harvest index ranged between 0.39 to 0.45 with a mean of 0.42. The highest (0.45) value of harvest index was observed under the treatments T_3-Rice (ADT 46) +Dhaincha (5:1) and T_8-Rice (Co 52) which were on par with T_1, T_2, T_4, T_5, and T_7 treatments and the lowest (0.39) value is observed under the treatment T_{10}-Rice (Navara). Significant differences between the treatments on harvest index during the *rabi* season was observed. Higher HI values lead to increased contribution for yield increment in ADT 46 and Co 52. This is in line with Parthasarathi *et al.* [22]. T_{10}-Rice (Navara) variety recorded lower harvest index (0.39). Production of less productive tillers per plant subsequently reduces both source and sink capacity which in turn reduced the grain and straw yield of Navara variety. Larger sink size, high remobilization of stored reserves and maintained biomass production after heading were responsible for the high harvest index.

The ultimate criterion for acceptability and widespread use of any technology is economics, and, cropping system technology is also no exception to this. Among several indices of economic efficiency in any production system, a net return has the greatest influence on the practical utility and adoption of the technology by farmers. In the present study economics of the different varieties showed that the highest (Rs. 123487 per ha) gross income was recorded in T_3-Rice (ADT 46) +Dhaincha (5:1) varieties because of higher value of produce and the lowest (Rs. 70452 per ha) was recorded in the treatment T_6- Rice (Bio fortified-CR Dhan45) varieties. The cost of cultivation is almost same in all the varieties which is (Rs. 51500 per ha). The highest (Rs. 71987 per ha) net income was recorded under T_3-Rice (ADT 46) +Dhaincha (5:1) and the lowest (Rs. 18952 ha) was observed under T_6- Rice (Bio fortified-CR Dhan45) varieties. The higher (2.40) benefit-cost ratio was observed in T_3-Rice (ADT 46) +Dhaincha (5:1) and the lower (1.37) was observed in T_6- Rice (Bio fortified-CR Dhan45) varieties.

Table 2. Effect of different treatments on test weight, grain, straw yield and harvest index of rice crop during *rabi* season

Treatments	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index
T_1-Rice (ADT 46)	22.5	5818	7298	0.44
T_2-Rice (ADT 46)	21.8	5434	7238	0.43
T_3-Rice (ADT 46) +Dhaincha (5:1)	24.1	6672	8219	0.45
T_4-Rice (ADT 46) +Dhaincha(10:1)	23.9	6198	8217	0.43
T_5-Rice (ADT 46)	22.1	5645	7492	0.43
T_6-Rice (Bio fortified-CR Dhan 45)	21.3	3677	5588	0.40
T_7-Rice (ADT 46)	21.4	5382	7109	0.43
T_8-Rice (Co 52)	22.8	6172	7437	0.45
T_9-Rice (Seeraga Samba)	21.2	3097	4199	0.42
T_{10}-Rice (Navara)	20.6	2322	3592	0.39
Mean	22.1	5041	6638	0.42
SEd	0.501	134.2	113.3	0.011
CD (0.05)	1.053	282	238	0.023

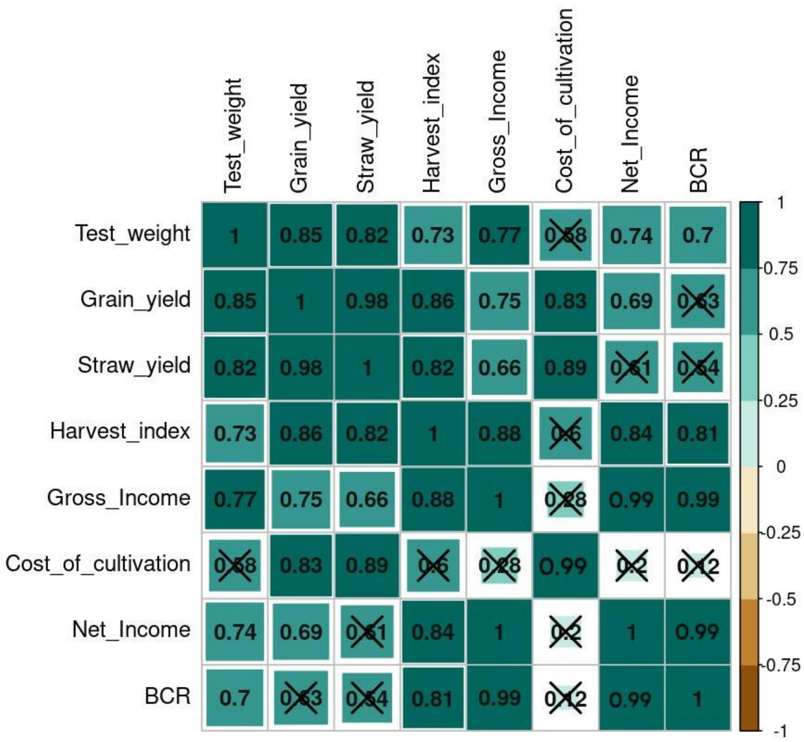

Fig. 1. Correlation analysis of different economic parameters

Table 3. Economics of different treatments

Treatments	Gross Income (Rs/ha/yr)	Cost of cultivation (Rs/ha/yr)	Net Income (Rs/ha/yr)	BCR
T_1-Rice (ADT 46)	111422	51500	59922	2.16
T_2-Rice (ADT 46)	105691	51500	54191	2.05
T_3-Rice (ADT 46) +Dhaincha (5:1)	123487	51500	71987	2.4
T_4-Rice (ADT 46) +Dhaincha(10:1)	118997	51500	67497	2.31
T_5-Rice (ADT 46)	105317	51500	53817	2.04
T_6-Rice (Bio fortified-CR Dhan 45)	70452	51500	18952	1.37
T_7-Rice (ADT 46)	102005	51500	50505	1.98
T_8-Rice (Co 52)	116274	51500	64774	2.26
T_9-Rice (Seeraga Samba)	107182	48500	58682	2.21
T_{10}-Rice (Navara)	85143	48500	36643	1.76
Mean	104597	50900	53696	2.05
SEd	2180.25	1167.84	1270.63	0.0460
CD (0.05)	4580.61	2543.58	2669.53	0.0967

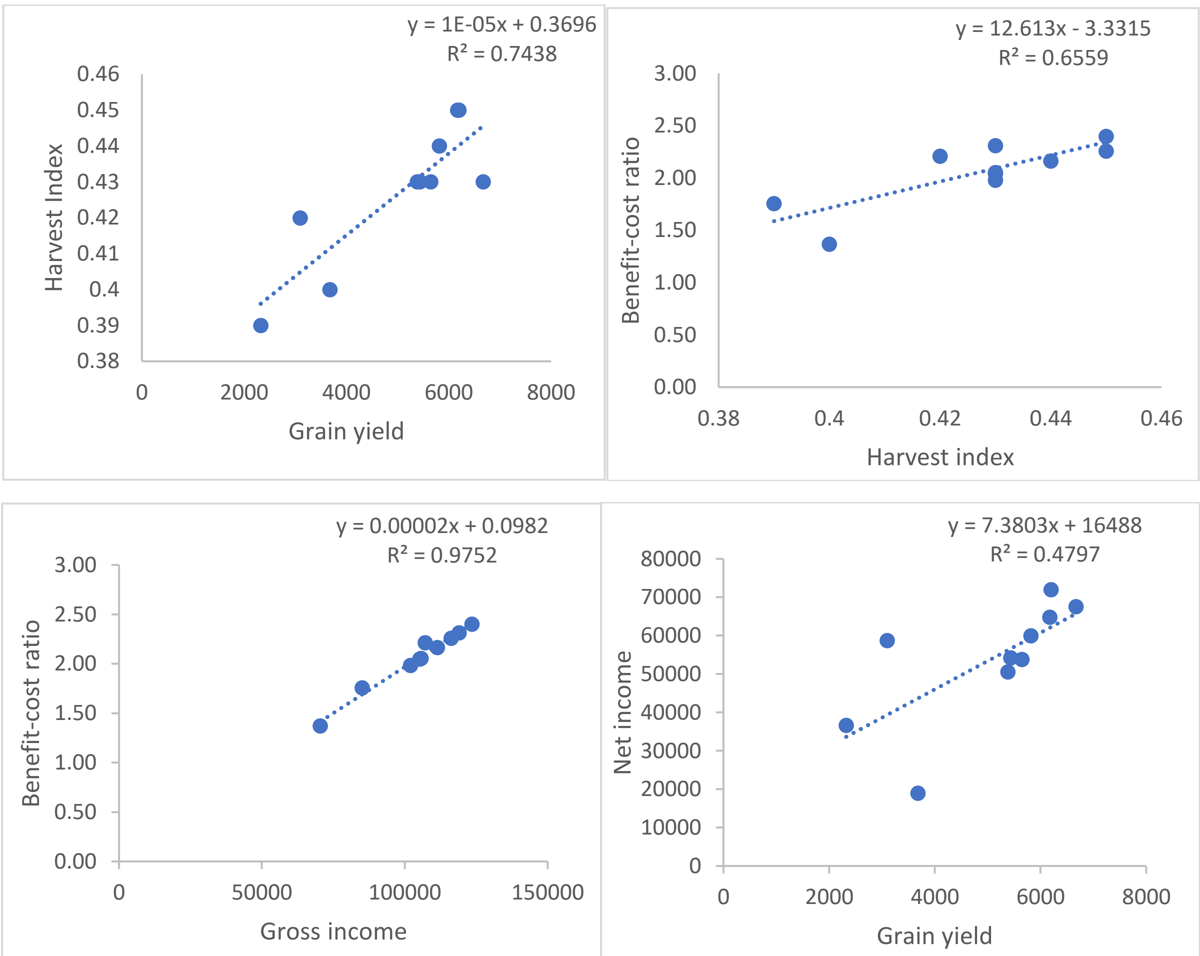

Fig. 2. Regression graphs and their equations of different economic and yield traits to study their strengths

3.1 Correlation Studies

Correlation studies were undertaken to examine the relationship between various yield traits and economic parameters of crops. The results revealed that grain yield exhibited a significant correlation, at a 95% significance level, with both gross income and net income. Moreover, a strong positive correlation, significant at the 99% level, was observed between grain yield and both test weight and harvest index (r =0.84, r=0.86). Notably, a significant positive correlation, also at the 99% level, was found between the benefit-cost ratio and harvest index (r =0.81). This implies that harvest index plays a crucial role in determining the benefit-cost ratio of the crop. Among the different rice treatments studied, the cost of cultivation showed a significant correlation, at the 99% level, with grain yield (r =0.83). However, no correlation was observed between the cost of cultivation and harvest index. This indicates that partitioning efficiency plays a pivotal role in determining the economic viability of the crop. Additionally, it was observed that the benefit-cost ratio exhibited a significant positive correlation, at the 99% level, with both gross and net incomes (r =0.99, r=1) [23].

3.2 Regression Analysis

The results of regression analysis showed that the benefit-cost ratio and harvest index had a significantly strong relationship having a positive slope and R^2 value of 0.656. However, the strength of the relationship between harvest index and grain yield was comparatively higher with an R^2 value of 0.744. Per unit change in grain yield, there was an increase of 7.380 units (slope) of net income was observed in the research. There was a strong relationship existed between the benefit-cost ratio and gross income having an R^2 value of 0.975 but the unit change in gross income didn't have a great impact on the benefit-cost ratio because the value of the slope that the graph showed was 0.00002. Also, there is a relationship between net income and grain yield with an R^2 value of around 0.480. Similar findings were reported by Kole and Hasib [24].

4. CONCLUSION

From the above-mentioned results and discussion, it could be concluded that the research study compared various treatments in rice cultivation, focusing on test weight, grain yield, straw yield, harvest index, gross income, cost of cultivation, net income, and benefit-cost ratio. The T_3-Rice (ADT 46) +Dhaincha (5:1) treatment stood out as the most superior option. The T_3-Rice (ADT 46) +Dhaincha (5:1) treatment demonstrated significant improvements in test weight, indicating healthier and denser grains with better market value. It also led to substantially higher grain and straw yields, showcasing enhanced productivity and efficient resource utilization. Incorporating Dhaincha into T_3-Rice (ADT 46) +Dhaincha (5:1) cultivation boosted the harvest index, ensuring more effective resource allocation towards grain production. This resulted in increased profits and greater economic benefits, as reflected in the gross income figures. Moreover, the T_3-Rice (ADT 46) +Dhaincha (5:1) treatment exhibited a competitive edge in cost-effectiveness by reducing expenses while maintaining high productivity, making it an attractive choice for farmers seeking to maximize profits sustainably. The net income analysis further highlighted the superiority of the T_3-Rice (ADT 46) +Dhaincha (5:1) treatment, indicating a potential for enhanced financial returns and improved livelihoods for farmers compared to other treatments. Lastly, the benefit-cost ratio (BCR) confirmed the economic viability and profitability of the T_3-Rice (ADT 46) +Dhaincha (5:1) treatment, making it a highly recommended practice for farmers.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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