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A Comparative study of Technical Efficiency of Selected Indian Commercial Banks by Data Envelopment Analysis based CCR and BCC Models

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Abstract

The efficiency and the quality provided by the banks plays a crucial role in the economic growth. In this competitive scenario banks are pushed to perform at their best efficiency. Higher efficiency is the sign of high profits and the higher survival. For analyzing efficiency the most significant method is the Data envelopment analysis method. The paper compared the two methods of the data envelopment analysis that is the CCR and BCC models. The empirical findings reveal that CCR model is essential to understand the efficient working of the banking industry. Further, technical efficiency of banks can improve when the scale of operation is ignored form the efficiency calculation.

Key Words: data envelopment analysis, technical efficiency, commercial banks.

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Introduction

Data Envelopment Analysis (DEA) Technique was originally developed and used to investigate the relative efficiency of not for-profit organizations; looking at its significance it was quickly adopted by profit-making organizations. It is "a non-parametric technique that generates a comparative ratio of weighted outputs to inputs for each decision making unit i.e. a relative efficiency score". DEA technique has many models to evaluate the efficiency and growth of organizations. CCR model and BCC model are the basic models of computing efficiency, wherein it requires making a prior choice of entities that are to be evaluated and the variables of *Input and Output* that are used for evaluation.

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Literature Review

(Bhattacharyya, Lovell, and Sahay 1997) examined the productive efficiency of Indian commercial banks during the ongoing period of liberalization. For the analysis of efficiency Stochastic frontier analysis method used in the study. The analysis found that during the ongoing period of liberalization public sector banks were found to be most efficient in comparison of private and foreign sector banks.

(Isik and Hassan 2002) determined the input and output efficiency of Turkish banking sector to understand the impact of cost, allocative, overall technical, pure technical and scale efficiency measures. The paper used the non parametric approach with the parametric approach. The result of the analysis showed that inefficiency was found in the Turkish banks because of the technical efficiency and not of the allocative inefficiency. Due to this diseconomies of scale were found in the result. The paper suggested that government should implement financial reform packages to boost the competition in the banking sector.

(Kumar, Malathy, and Ganesh 2010) determine the influence of technological change in the banking sector of India. In the analysis DEA method has been used to determine the efficiency of Indian banking sector and bank groups. The result of the analysis found that technology and innovation has greater impact than efficiency change. Total factor productivity change and its component fund that bank size and ownership have a significant effect on technical change.

(Chan 2011) assessed the technical efficiency of commercial banks of china. The paper decomposed the technical efficiency into pure technical and scale efficiency to determine the inefficiencies in the Chinese banks. The result of the analysis showed that the banks in China are on an average technically inefficient. They face the problem of allocation of resources between its input and output mix. The paper noted a positive impact of china's entry in WTO and the gradual deregulation of the Chinese banking sector on the banking efficiency.

(Goyal et al. 2018) assessed the intra sector efficiency of Indian banking sector. Cross sectional data used in the paper to analyze the efficiency of banks operating in India during the period 2015-16. The paper used directional distance function based DEA approach. the result of the analysis showed that Indian banking sector is 73.44% efficient during the analysis period. The analysis also confirmed the existence of different production functions across different ownership structures. The finding of the study fully support the

recommendations of Reserve bank of India that to retain fewer but healthier banks in the market.

(Tamatam, R., Dutta, P., Dutta, G. and Lessmann 2019) estimated the relative efficiency of Indian commercial banks by employing various models of data envelopment analysis. The paper also provided the comparative analysis of used models. The study also used the malaquist indices to determine the performance and productivity of the Indian banks. the found that 9 out of 38 banks were found technically efficient. The comparative study found that public sector and private sector banks were similarly efficient. The result of malmquist index proves that public sector banks have a higher increase in productivity in comparison to public sector banks.

Research Design: For this research work after an exploratory research about numerous various banks belonging to public and private ownership in the banking sector is carried out. Based on this, the variables for measuring the efficiency of banks were selected for the present study. The present study is based on the following major objectives:

1. To compute and study Technical Efficiency (TE) of selected commercial banks by CRR model.
2. To compute and study Pure Technical Efficiency (PTE) of selected commercial banks by BCC model.
3. To compare the results of efficiency scores obtained by CRR model and BCC model.

Period of the Study: The study period is for last 10 years; i.e. from 2009-10 to 2018-19. Data of the selected commercial banks is collected for a time period of ten years; beginning from 2009 up to 2019. Data on the selected variable is collected for carrying out the present study.

Data Sources and Data Collection: Secondary data collection method is employed for collection of data for the present study. Thus the study completely relies on the secondary data collected from various sources, and website of commercial banks. Annual reports of selected commercial banks are thoroughly studied and analyzed for seeking the necessary information.

Sample Size & Sample Selection: The sample size of the present study is the number of commercial banks selected from the total population. 16 (sixteen) commercial banks in total belonging to public sector banks and private sectors banks are selected for the present

study. 08 (eight) banks form public sector and 8 (eight) banks from private sector are selected for the present study. They form the sample size for the study. Based on the rule of thumb generally found in the DEA literature stats that two times the number of input and output when added should not be less than total number of DMU's(Tamatam, R., Dutta, P., Dutta, G. and Lessmann 2019). In the present study Stratified Random Sampling is used for choosing commercial banks from the public sector and private sector of the Indian banking sector.

Data Analysis: The present section deals with the measures, statistical techniques and econometric models employed to analyzed the collected data. For computing the efficiency of the selected banks Data Envelopment Analysis (DEA) Technique is employed. DEA Software – DEAP Version 2.1 is used for data analysis.

Data Envelopment Analysis (DEA) Technique: DEA method is simpler method of computing efficiency, wherein it requires making a prior choice of entities that are to be evaluated and the variables of *Input and Output* that are used for evaluation. The entities that are to be evaluated for their efficiency are termed as 'Decision Making Units (DMUs)'. DMUs are evaluated because they are regarded as being responsible for converting inputs into outputs, deciding their efficiency of operation. DEA is a non-parametric technique that generates a relative efficiency score for each DMU. The relative efficiency score is usually reported as a number between 0-1. The number 1 denotes 100% efficiency. A unit with a score less than 100% is regarded as inefficient as compared to other units/ DMUs in the sample. The list of decision making units selected for the DEA model in the present study is presented in table 1.

Table 1

List of Decision Making Units (DMUs) for DEA Model

DMU	**Name of the Bank**
DMU 1	State Bank of India (SBI)
DMU 2	Punjab National Bank (PNB)
DMU 3	Canara Bank
DMU 4	United Commercial Bank (UCO)
DMU 5	Bank of Baroda (BOB)
DMU 6	Union Bank of India
DMU 7	Bank of India (BOI)
DMU 8	Indian Overseas Bank

DMU 9	Industrial Credit and Investment Corporation of India (ICICI)
DMU 10	The Housing Development Finance Corporation Limited Bank (HDFC)
DMU 11	Axis Bank
DMU 12	Kotak Mahindra Bank
DMU 13	Federal Bank
DMU 14	IndusInd Bank
DMU 15	KarurVysya
DMU 16	South India Bank

For the purpose of DEA analysis, Linear equations are to be framed based on the variables selected as Input variables & Output variables. Thus the above variables are categorized into 'Input' and 'Output' as given below.

The description of various banking companies selected as DMUs for the present study is presented. In total sixteen (16) banks are selected as DMUs for applying DEA models. Eight (08) banks belong to public banking sector whereas eight (08) banks belong to private sector of the banking industry. Data on different variables is collected, namely: Deposits, Borrowings, Fixed Assets, Number of Employees, Number of Branches, Loans & Advances, Investments, and Interest & other income.

For the purpose of designing DEA model, five variables are selected as 'Input' variable and three as 'Output' variable. Table 2 shows the Input & Output variables for DEA modeling.

Table 2

Input & Output variables for DEA modeling

Variable	***Notation***	***Input/ Output Variable***
Deposits	(I)X_1	Input Variable
Borrowings	(I)X_2	Input Variable
Fixed Assets	(I)X_3	Input Variable
Number of Employees	(I)X_4	Input Variable
Number of Branches	(I)X_5	Input Variable
Loans & Advances	(O)Y_1	Output Variable
Investments	(O)Y_2	Output Variable
Interest & other income	(O)Y_3	Output Variable

DEA based CRR Model: The CCR model was initially proposed by Charnes, Cooper and Rhodes in the year 1978. This model assumes constant return to scale. Under the CCR model, overall efficiency of DMU is calculated; in which its Technical efficiency and Scale efficiency, both are aggregated. For application of CCR model it is assumed that a DMU operate under constant return to scale. In other words, an increase in Input will results in proportionate increase in Output of the DMU under consideration. Envelopment surface obtained by the CCR model for all the DMUs has shape of a convex cone. Efficient DMU will fall on the top of the curve, whereas inefficient DMUs will be covered under the cone. Under the CCR model, overall efficiency of DMU is calculated; in which its Technical efficiency (TE) and Scale efficiency (SE), both are aggregated. This method evaluates the overall efficiency (OE) of DMU and identifies the efficient DMU and non-efficient DMU from the total DMUs under consideration.

The model can be put to use in two ways:
(a) Input oriented way: Input oriented model, focus on increasing the efficiency of a DMU by decreasing the inputs keeping the output level constant. This is the *Minimization* model.
(b) Output oriented way: Output oriented model focus on increasing the output keeping the input level constant. This is the *Maximisation* model.

DEA based BCC Model: The BCC model was proposed by three researchers -Banker, Charnes & Cooper in 1984. BCC models compute Pure Technical Efficiency of a DMU. It assumes Variable return to scale. In other words, it assumes that changing inputs may not necessarily result in a proportional change in outputs of a DMU. Pure technical efficiency ignores the impact of Scale efficiency. In this model a DMU is compared to another DMU of similar scale, thus scale size is compared in this model. The envelopment obtained by BCC model is a Convex Hull. Efficiency obtained by BCC model is part of the efficiency obtained by CCR model.

BCC models compute Pure Technical Efficiency (PTE) of a DMU. It assumes Variable return to scale. In other words, it assumes that changing inputs may not necessarily result in a proportional change in outputs of a DMU. Pure technical efficiency (PTE) ignores the impact of Scale efficiency (SE). In this model a DMU is compared to another DMU of similar scale, thus scale size is compared in this model. The envelopment obtained by BCC

model is a Convex Hull. Efficiency obtained by BCC model is part of the efficiency obtained by CCR model.

Comparison of Results by CCR model and BCC model

The comparison of results by CRR model and BCC model is presented in the following table. Table 3 shows the number of efficient DMUs and number of inefficient DMUs as per the CRR model and BCC models. The overall efficiency shown by CRR model and the Pure Technical efficiency shown by the BCC model has the effect on the number of DMUs that are effective.

Table 3

Comparison of CRR model and BCC model

	CRR model		**BCC model**	
Year	No. of Efficient DMUs	No. of Inefficient DMUs	No. of Efficient DMUs	No. of Inefficient DMUs
2009-10	12	4	14	2
2010-11	11	5	13	3
2011-12	10	6	15	1
2012-13	13	3	15	1
2013-14	13	3	15	1
2014-15	13	3	13	3
2015-16	13	3	14	2
2016-17	13	3	14	2
2017-18	12	4	15	1
2018-19	9	7	12	4

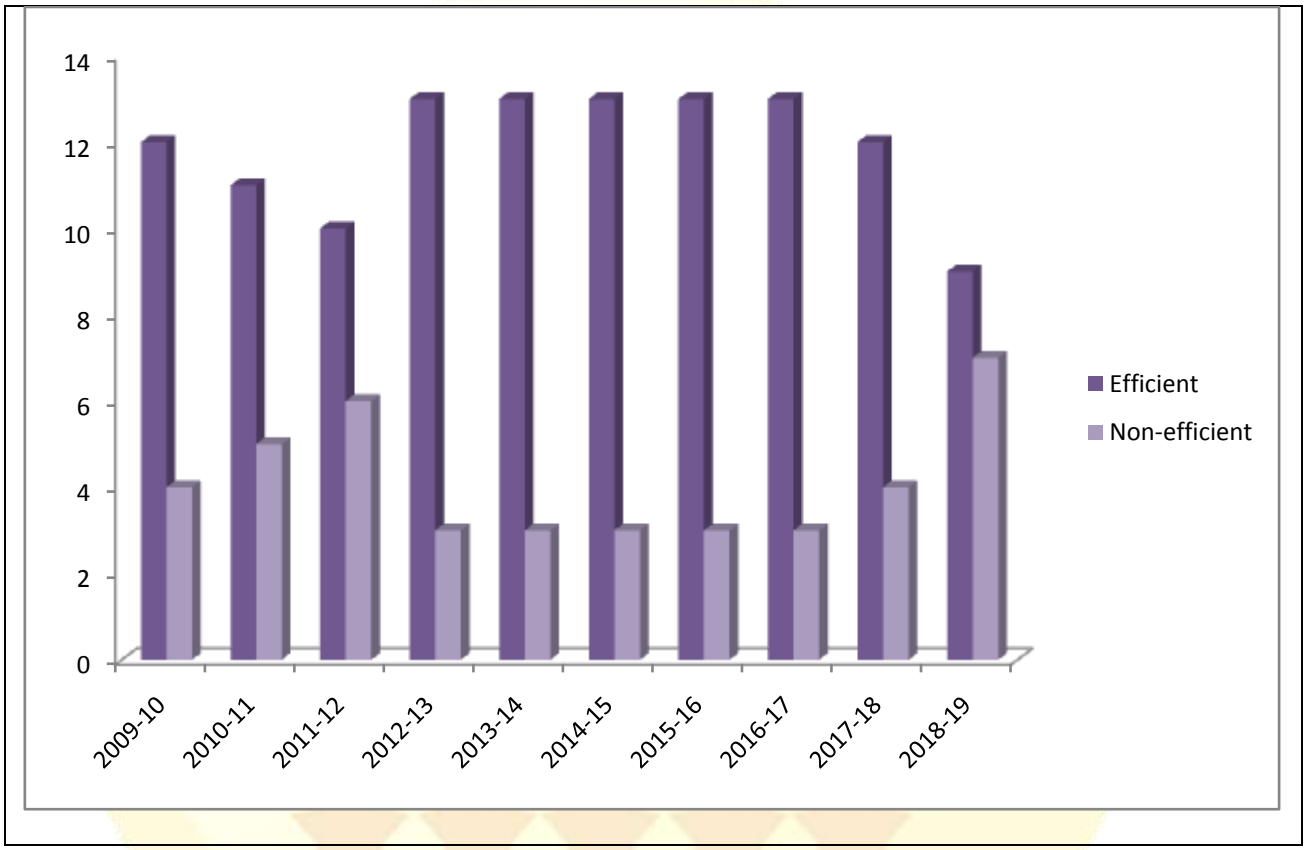
Analysis of table 3 shows that the number of Effective DMUs has increased for each year under analysis. For 2009-10, there is increase of 2 efficient DMUs thus reducing the number of inefficient DMUs to 2. Similar results are seen for the rest of the years under the present study. There is increase in number of efficient DMUs when only the Pure Technical Efficiency (PTE) is calculated as per the BCC model. The number of efficient

DMUs decreases when the Overall Efficiency (OE) is calculated as per CRR model. This may be due to the effect of scale size of the DMUs that adversely affected the efficiency scores.

Following figure graphically depicts the efficient and non-efficient DMUs as per the CRR model for each year of the time period under consideration of the present study.

Figure 1

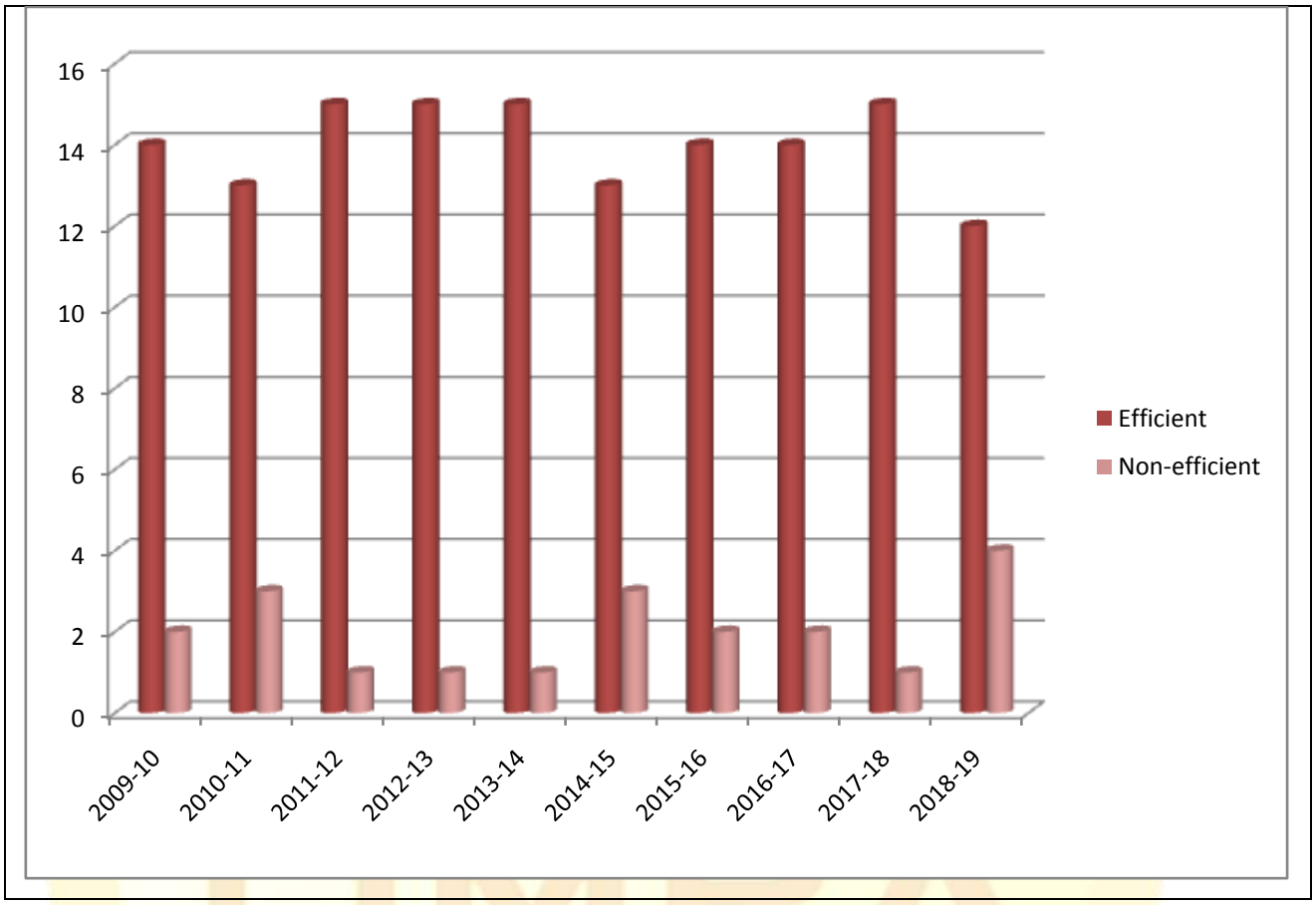
Number of Efficient and Non-efficient DMUs as per CCR Model



Analysis of the above figure show that the number of non-efficient DMU increased for the first three years; i.e. from 2009-10, 2010-11 and 2011-12. The number of non-efficient DMU remained 3 for the time period from 2012-13 to 2016-17. Thereafter there was an increase in the number of inefficient DMUs.

Figure 2

Number of Efficient and Non-efficient DMUs as per BCC Model



The above figure graphically depicts the efficient and non-efficient DMUs from 2009-10 to 2018-19 as per BCC Model of DEA technique. The comparison of average score by both the models is presented in the following table. Table 4 shows the Average score of 16 DMUs by CRR model and BCC model of DEA technique. Year wise average efficiency of the DMUs is presented.

Table 4

Comparison of Average Efficiency by CRR model and BCC model

	CRR model	BCC model
Year	**Average Score**	**Average Score**
2009-10	0.9766	0.9839
2010-11	0.9884	0.9962
2011-12	0.9910	0.9962
2012-13	0.9975	0.9994
2013-14	0.9905	0.9981

2014-15	0.9866	0.9883
2015-16	0.9895	0.9947
2016-17	0.9911	0.9988
2017-18	0.9769	0.9967
2018-19	0.9769	0.9925

Analysis of table 4 shows that, the average efficiency of the selected DMUs range from 97% to 99% for the given time period; i.e. from 2009-10 to 2018-19. The average efficiency for each year is improved from the CRR model to BCC model showing that BCC model is a better indicator of efficiency of DMUs selected from the banking industry for the present study. The technical efficiency of banking companies is better when the scale of operation is ignored from the efficiency calculation.

Figure 3

Comparison of CRR (CRS) and BCC (VRS) models of DEA Technique

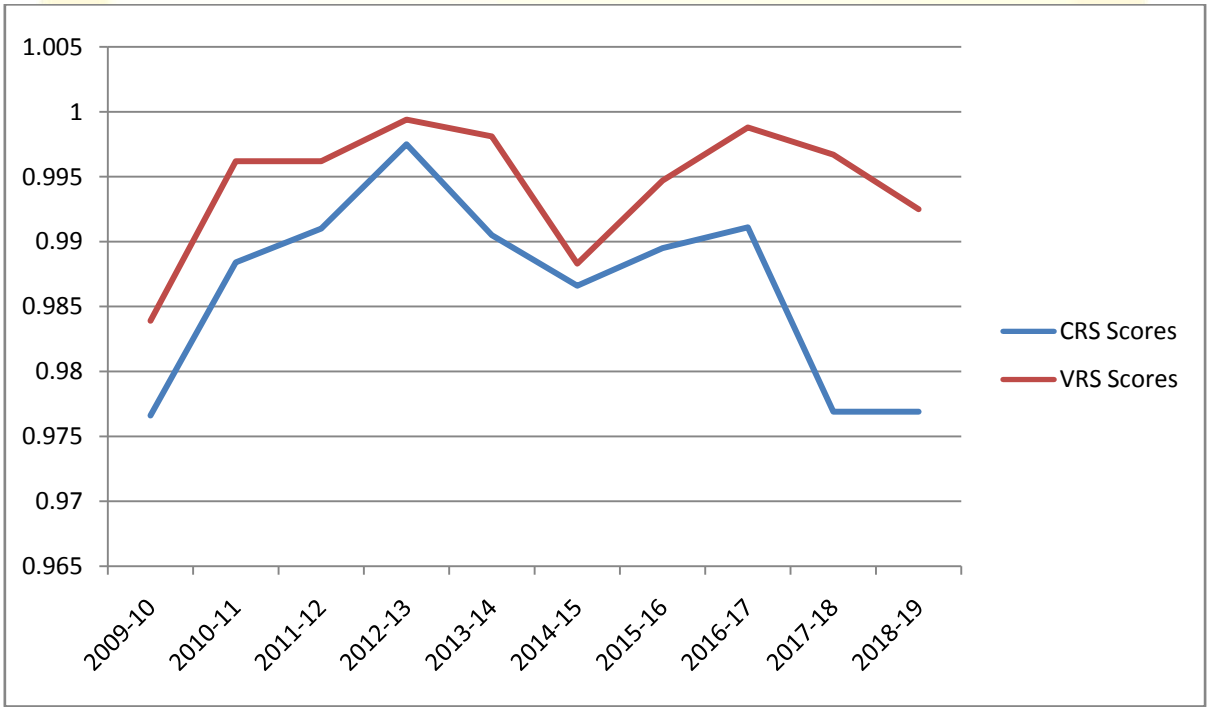


Figure 3 shows the average Overall Efficiency (OE) and Pure Technical Efficiency (PTE) scores of the DMUs under consideration of the present study. For the year 2014-15 and 2015-16 there is decrease in the overall efficiency and again a dip is seen in the year 2017-18. For the year 2018-19 the results reveal that OE remained same as the previous year and the PTE showed a small improvement.

Conclusion

As compared to CRR model, the BCC model shows improvement in the efficiency of selected banks. Thus the variable return to scale model is applicable for finding the efficiency of banks. However as per theory, banking industry fall under the constant return category. Thus analysis by CRR model is essential to understand the efficient working of the banking industry. It can be seen that the VRS scores obtained from the BCC model of DEA technique shows improved the average efficiency of the banking companies selected for the present study.

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