The characteristics of the repair and maintenance costs distribution of rice combine harvester in Malaysian paddy fields

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Abstract: The main objective of this study is to characterize the repair and maintenance (R&M) costs distribution of rice combine harvesters in the Malaysian paddy field. The survey method through face-to-face interviews was used to collect the data and relevant information from the owners of sampled combine harvester at rice granaries in Langkawi and Kota Setar districts of Kedah state, in the Northern Region of Peninsular Malaysia. The data and information collected includes annual R&M costs and activities, components to be replaced, and their portion of the total R&M costs. The findings showed that the mean R&M costs distribution of combine harvester during off-season was 3.92 times higher than the on-season. Repairing pump bush track, wheel, conveyor belt, wheel bearing, soucy track, straw walker and header are among the components that took large portions of mean R&M costs during off-season. Meanwhile during on-season, repairing the ground speed vari-drive, wheel shaft, cutting knife, grain elevator drive, and lubricant oil consumed large portions of mean R&M costs.

Keywords: combine harvesters, machinery management, mechanization, rice harvesting

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1 Introduction

Paddy is listed in the top three of agricultural crops planted in Malaysia. The Department of Agriculture (DOA) Peninsular Malaysia (2015) stated that, the planted areas of this crop in year 2014 were 679,239 ha and considered as the third largest planted areas in the country after oil palm and rubber. With such hectareage of planted areas, the DOA (2015) reported that Malaysia produced 2,848,559 metric tons of paddy.

Likewise, with other sectors, the production process of rice in Malaysia also faces the labor shortage problem due to shifting the country's economy scenario from agricultural to industrial and services sectors. Consequently, mechanization has been implemented by the Malaysian government to replace labor intensive use in the sector.

Nowadays, mechanized harvesting system using combine harvester is the most progressive implementation of mechanization in Malaysian paddy field. Currently, 100% of rice harvesting activity in Peninsular Malaysia has been mechanized as published in a survey report (DOA, 2014). The degree of mechanization in harvesting activity is the same with the land preparation activity; nonetheless it is greater than transplanting (2.1%), direct seeding (80.7%), fertilizer application (76.9%), and crop spraying (85.6%) activities (DOA, 2014).

In line with the fast growing of mechanization in rice harvesting in Malaysia, the country's import value on combine harvesters also had also increased 3.86 times from USD$660,000 in 2005 to USD$ 2,547,000 in 2009 (FAOSTAT, 2016).

Studies concerning combine harvester costs in Malaysian paddy field that revealed in the research literatures are very scarce and more focused on technical aspects such as evaluation of its field performances, and development and evaluation of its yield monitoring

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system (Husaain and Ismail, 1983; Roy et al., 2003; Kin et al., 2011; Putri et al., 2016). Another study looked at the social and economic aspects of combine harvester in the Muda region of Malaysia (Ayob, 1979). However, this study does not specifically investigate costs of the machine in details. He only emphasized the economics and adoption of the combine harvester.

Since combine harvester has been commonly used in Malaysian paddy field, thus, one of the important elements should be looked at seriously is the operating costs of combine harvester in order the machine will be economical and give a satisfactory profit to the owners. To achieve that, the owners should be capable of estimating the costs. Siemens et al. (2008) mentioned that accurately estimate farm machinery costs would be an important step to come up with profits of farm business.

Therefore, repair and maintenance (R&M) costs are among essential farm machinery operating costs that need to be considered in utilizing a combine harvester in paddy field. According to Buckmaster (2003), Mazzetto and Calcante (2010), costs for repairing and maintaining farm machinery is one of the most considerable costs of the agricultural sector, beside purchasing cost. Khodabakhshian and Shakeri (2011) also stressed that estimating R&M costs are important for farm machinery replacement decisions and for overall farm budgeting.

Importantly, Siemens et al. (2008) highlighted that repair costs of specific farm machinery are also influenced by geographical section of a country. The amount of repair will vary from one geographical condition of a country to another because differences in soil, crops, climate and operators. Numerous researchers have studied on estimates repair costs of farm machinery (Bowers and Hunt, 1970; Ward et al., 1985; Lips, 2013; Calcante et al., 2013). However, the information obtained from these previous studies were the R&M costs of tractors based on their own countries. A previous study on combine harvester costs was reported by (Calcante et al., 2013b). Nevertheless, the focus of study was in Italy, which its geographical conditions are very much different from Malaysian paddy fields.

Thus, the main objective of this study is to record basic information concerning the characteristics of the R&M costs distribution of combine harvester with respect of Malaysian paddy field. The information consists of the seasonal repairs and maintenance activities, components to be replaced, and their portion of the total R&M costs of combine harvester. Other general information from the owners of combine harvesters is also compiled and discussed. This study would be useful as foundation of knowledge to the owners of combine harvester in managing their machines to be more efficient and competitive.

2 Materials and methods

2.1 Data collection

Information on the R&M costs of combine harvesters were collected from the owners of the machines at rice granaries in the districts of Langkawi and Kota Setar, Kedah from the month of January 2016 till Mach 2016. The areas are under the management of MADA (Muda Agriculture Development Authority**),** which is located in the northern region of Peninsular Malaysia. The MADA itself is a Malaysia's government agency that functions to develop the country's self-sufficiency level in paddy and rice production at main paddy producing areas (Muda Agriculture Development Authority, 2016).

The study areas were planted with several certified varieties of paddy such as MR219, MR220, MR253, MR263 CL1 and MR263 CL2. Moisture content of harvested paddy during the study was in-between 10% to 14%, while soil moisture content in the field varied from 12% to 40%.

A survey method through face-to-face interviews was used to collect the data and relevant information of R&M costs from the owners of sampled combine harvesters. Face-to-face interviews was chosen because this method was considered as the most effective and easiest way to collect data from the respondents in survey research method (Lavrakas, 2008). A total of 33 units of combine harvesters with engine power size ranged from 380 to 450 horsepower (HP) and age of 4 to 20 years were sampled in this study. They were selected randomly. The number of samples was sufficient to represent 95% population of combine harvesters in the study area. During interview, the owners of sampled combine harvesters were requested to fill the ready-made survey forms, which comprised of several questions that related to the repairs and maintenance activities performed on their combine harvesters during on-season and off-season.

We defined on-season repairs and maintenance activities as all repairs and maintenance activities that were performed by the owners of combine harvester when the machines are being used in the paddy field during harvesting season. At that time, the demands of combine harvesters to serve the harvested areas are high. Meanwhile, off-season repairs and maintenance activities refer to all repairs and maintenance activities that were performed at the end-of- harvesting season. At that time, the combine harvesters get off from work while waiting for the upcoming harvesting season.

2.2 Data analysis

Data were analyzed by using spreadsheet software that averaged the R&M costs, which were allocated by the owners of the sampled combine harvesters. The components to be replaced and their portion of the total R&M costs spent for combine harvester were described by using descriptive statistic. The descriptive statistic is one of the data analysis techniques that commonly used by researchers in survey research to characterize and summarize the collected data (Lavrakas, 2008). General comments on brand of combine harvesters, seasonal use of the machines, operator's age and year of experience, and repairs and maintenance activities performed by the owners were also reviewed and encompassed in data analysis.

3 Results and discussion

Table 1 summarizes the distribution of the sampled combine harvesters by the brands. The most popular brand used in the study area was New Holland 1545 combine harvester, which took 63.64% of total 33 samples, while the least was Laverda (3.03%). Generally, the brand of combine harvester was selected by the users based on their own operating experience using that brand. This is consistent with a statement saying that the most important factor in determining what agricultural machine a farmer will purchase is their own operating experience (Donnelly, 2015).

Table 2 shows the distribution of sampled combine harvesters by age. The data indicates that 18.18% of the combine harvesters' age ranged from 0 to 10 years. These age groups are considered as a standard ownership period, which is within an acceptable range of economic machine lifespan. Meanwhile, 81.82% of the total combine harvesters in this study aged more than ten years (11 years and above). Such age groups are believed very risky machine lifespan due to the dangers of obsolescence, high repair bills and loss of reliability (Siemens et al., 2008; Samsudin et al., 2017)

Table 1 Distribution of the sampled combine harvesters by brand

Brand of combine harvester	Quantity	Percentage (%)
New Holland 1545	21	63.64
New Holland 1550	6	18.18
New Holland 8060	5	15.15
Laverda	1	3.03
Total	33	100.00

Table 2 Distribution of sampled combine harvesters by age

Combine harvester age (years)	Quantity	Percentage (%)
0-10	6	18.18
11 and above	27	81.82
Total	33	100.00

Table 3 shows the distribution of combine harvesters by their seasonal uses. The seasonal uses of combine harvesters ranging from 601 to 900 hours were dominantly found in the study area. This range took 42.42% of the whole grouped ranges. The lowest seasonal use was 300 hours and below, and it was only practiced by 6.06% of the owners of combine harvesters. Other larger seasonal uses were also found at the respective rate of use of 301 to 600 hours (30.30%) and 901 to 1200 hours (12.12%). Meanwhile, seasonal use of 1201 hours and above was applied by 9.09% of the owners. With reference to twice seasons of rice cultivation in a year in Peninsular Malaysia and along with the data of seasonal use as presented in Table 3, it can be said that the use of combine harvesters during harvesting in the study area are considered as a high rate annual use. This is agreeing with Siemens et al. (2008), which considers that the rate of annual use of self-propelled combines close to 400 hours are categorized as high rate of annual use. Normally, major repairs and maintenance activities or routine overhaul to reinstate the original performance of the machines was conducted by the owners of combine during off-season or when the harvesting seasons ended. Throughout that period, thorough services and inspections were made over the machine's conditions. Also, lots of major components need to be replaced due to they are worn-out or broken after fully utilized during on-season in the field. This is consistent with (Siemens et al., 2008), who states that repairing the worn-out machinery is a crucial thing since there is a tremendous difference in the total time from new to worn out.

Table 3 Distribution of the sampled combine harvesters by seasonal use

Range of seasonal use (hours)	Quantity	Percentage (%)
≤300	2	6.06
301-600	10	30.30
601-900	14	42.42
901-1200	4	12.12
≥1201	3	9.09
Total	33	100.00

Table 4 summarizes the distribution of combine harvesters' operators by age and year of experience ranges. Operators' age 31 to 40 years were the largest group (54.60%) that operate combine harvesters in Malaysian paddy field, while operators age 41 to 50 years were the least (3.03%). The operators mostly have working experience of 6 to 10 years (27.27%). Percentage of operators having 21 years onwards working experience were the smallest (9.09%).

More or less 72.70% of the owners of combine harvesters in study area have skills to do repairs and maintenance to their own machines in their farm workshop, while the rests hire mechanics or send the machines to workshop outside their farm. The owners said that the repairs and maintenance activities are conducted twice a year. Usually these activities take about one month. Besides, generally, the years of working experience of operators in the study areas are good. This is showed by the percentage of operators with working experience at 11 to 15 years also quite high (24.24%). The operators with age range of 31 to 40 years were recorded 54.60% or considered as the highest percentage of among the group of operators' age range. This age range reveals that the operators of combine harvesters in the study areas fall into young adults' category. Under that category, they are mostly in good health, physically strong and productive as well as (Charles and Kirst-Ashman, 2016).

Table 4 Distribution of combine harvesters' operators by age and year of experience

Parameter		Quantity	Percentage (%)
Age range (years)	20-30	14	42.42
	31-40	18	54.55
	41-50	1	3.03
Year of experience range (years)	1- 5	9	27.27
	6 - 10	9	27.27
	11-15	8	24.24
	16-20	4	12.12
	≥ 21	3	9.09

3.1 R&M costs distribution of combine harvester by seasonal use

Table 5 presents the summary of R&M costs of combine harvesters by seasonal use in the area of study. The mean off-seasonal R&M costs were USD$3,307.92, which varies from minimum of USD$135.50 to maximum of USD$8,251.75. The mean on-seasonal R&M costs were USD$844.00 USD and also fluctuate from minimum of USD$356.50 and maximum of USD$1,502.25. The mean off-seasonal R&M costs were 3.92 times greater than the on-seasonal R&M costs. Based on the sum of mean R&M costs of both seasons in Table 5, thus, mean annual R&M costs for combine harvesters was USD$4152.12.

Table 5 Summary of R & M costs of combine harvesters by seasonal use

Parameter	On-seasonal R&M cost (USD$)	Off-seasonal R&M cost (USD$)
Mean	844.20	3,307.92
SD	252.00	1,568.31
Max	1,502.25	8,251.75
Minimum	356.50	135.50

3.2 R&M costs distribution of combine harvester by components

Table 6 shows the distribution of mean off-seasonal R&M costs of combine harvesters by components. During off-season, large portions of the mean R&M costs were spent for repairing pump bush track (13.28%), wheel (10.00%), conveyor belt (9.58%), wheel bearing (9.46%), soucy track (8.70%), straw walker (8.47%) and header (7.90%).

Pump bush track, wheel, wheel bearing and soucy track are among the major components that worn-out easily during off-season and they have to be replaced because of clay soil properties and soft terrains conditions. Paddy fields have particular characteristic, which that areas should be always flooded since beginning of its cultivation. Flood-free areas is only prepared at harvesting seasons. Thus, high water table and low permeable top soils are among the factors that caused waterlogged during harvesting seasons and can deteriorate the final drive components of combine harvesters. Conveyor belt is replaced after harvesting season ended, because it was easily cracked or damaged. The same thing also goes straw walker. Header is regularly repaired during off-seasons to eliminate any failure or delay when the machine works during harvesting season. Others components such as track plate, hydraulic oil, unload grain chain, wheel shaft, sieve belt, reel drive, knife drive and cutting knife only took less than 1% of mean R&M costs spent during off-season.

Table 6 Distribution of mean off-seasonal R&M costs of combine harvesters by components

Components	Mean R&M costs (USD$)	Percentage of mean R&M costs (%)	Rank
Pump bush track	439.29	13.28	1
Wheel	330.79	10.00	2
Conveyor belt	316.90	9.58	3
Wheel bearing	312.93	9.46	4
Soucy track	287.79	8.70	5
Straw walker	280.18	8.47	6
Header	261.33	7.90	7
Pump bush lock	223.28	6.75	8
Roller	218.32	6.60	9
Sieve	119.09	3.60	10
Grain elevator drive	102.21	3.09	11
Gearbox oil	86.01	2.60	12
Hydraulic system	60.53	1.83	13
Sprocket track	55.24	1.67	14
Engine	49.29	1.49	15
Lubricant oil	48.96	1.48	16
Painting	45.65	1.38	17
Grease	37.05	1.12	18
Others	33.08	1.00	19
Total	3,307.92	100	

Table 7 shows the distribution of mean on-seasonal R&M costs of combine harvesters by components. Throughout on-season, large segment of the mean total R&M costs were expanded for repairing ground speed vari-drive (23.91%), wheel shaft (18.13%), cutting knife (10.51%), grain elevator drive (8.79%), and lubricant oil (8.28%).

From general information obtained through face-to-face interviews, it was told that the modification on the final drive of combine harvester was necessary before operating the machine in Malaysian paddy field. This is because all the machines are imported from their countries of origin, where their land and operating conditions are very different from Malaysia. The original design of front final drive on the imported combine harvester is equipped with rubber wheel system. This part must be modified to be the soucy track system which gives better traction and stability on the Malaysian paddy fields.

Table 7 Distribution of mean on-seasonal R&M costs of combine harvesters by components

Components	Mean R&M costs (USD$)	Percentage of mean R&M costs (%)	Rank
Ground speed vari-drive	201.88	23.91	1
Wheel shaft	153.02	18.13	2
Cutting knife	88.70	10.51	3
Grain elevator drive	74.24	8.79	4
Lubricant oil	69.92	8.28	5
Grease oil	45.11	5.34	6
Sieve belt	43.89	5.20	7
Sieve	34.84	4.13	8
Hydraulic oil	34.76	4.12	9
Reel speed bearing puller	32.07	3.80	10
Grain unloader chain	23.80	2.82	11
Reel drive	14.26	1.69	12
Roller bearing	10.55	1.25	13
Knife drive	8.71	1.03	14
Others	8.44	1.00	15
Total	844.20	100	

During on-season, normally ground speed vari-drive is simply broken because of lubricant oil leaking. Wheels shaft needs additional services during the machines working to smooth its functions. The cutting knife is very easily to be blunted and broken when hitting the harder soil clods or small stones during cutting paddy. Grain elevators drive is easily loose that cause the harvested grain cannot be transferred to the grain tank. Lubricant oil is necessary during machine working in order to avoid wear and tear the components. The lowest portion or less than 1% of the mean of total R&M costs during on-seasons were used for repairing track plate, wheels bearing, and hydraulic system leaking.

With twice growing seasons per year that commonly practiced by the farmers in Malaysian paddy fields, thus, it was found that about all the owners of combine harvesters have used their machines at the maximum rate of annual use. In fact, the rate of annual used are very extremely higher when compared to the maximum annual use at 400 hours of self-propelled combine harvesters in

USA and at 367 hours of combine harvesters in Italy (Bowers, 2008; Calcante et al., 2013b). The excessive amount of seasonal use of combine harvesters used in the study areas could indicates that the number of the machines are not enough to cater the assigned areas at normal working hours commitment during harvesting seasons. According to Guadagni and Fileccia (2009), normally, a combine harvester can serve a large area of 200 to 250 ha. However, in the study areas, it was recorded that a combine harvester has to serve a large area of 323 ha. It was calculated by dividing the total rice granary areas in the districts of Kota Setar (6964 ha) and Langkawi (3712 ha) with number of available combine harvesters. Due to insufficient number of combine harvesters, it is not surprising sometimes the machines must lengthen working hours in the field even until night time to complete the assigned harvesting areas. Whereas, exceeding the hours of use could affects the R&M cost. This is agreeing with Siemens et al. (2008), who said that the longer machinery is used, the more repairs are needed to maintain its reliability.

The mean on-seasonal R&M costs were cheaper than that of the off-season since thorough inspections and services over machines have been completed during off-season. This practice eliminates or reduces possibility of machine breakdowns when working in the fields during on-season. Therefore, when operating during on-season, the machine is in its own peak performance.

4 Conclusions

The nature of the R&M costs distribution of combine harvester and R&M activities with respect of Malaysian paddy fields conditions has been successfully explored. Generally, the study has provided a fruitful basic information and foundation of knowledge for the owners of combine harvesters in managing the costs of their machinery. Mean annual R&M costs for combine harvesters Malaysian paddy fields was USD$4152.12. This amount is computed based on the sum of mean on-season and off-season R&M costs.

On seasonal use basis, the results had showed that large portion of total mean R&M costs were used for repair and maintenance activities during off-season, which was 3.92 times greater than the costs of on-season.

On components basis, the vast portions of the R&M costs during off-season were given for repairing pump bush track (13.28%), wheel (10.00%), conveyor belt (9.58%), wheel bearing (9.46%), soucy track (8.70%), straw walker (8.47%) and header (7.90%). Meanwhile, during on-season, the percentage of mean total R&M costs were distributed to repair ground speed vari-drive (23.91%), wheel shaft (18.13%), cutting knife (10.51%), grain elevator drive (8.79%), and lubricant oil (8.28%).

The most recorded range of seasonal use of combine harvesters was 601 to 900 hours per season. The range showed that most the machines have been exceeded the recommended optimum seasonal use. This is also an indicator that the numbers of combine harvesters in the study area are not adequate to supply the amount of jobs during harvesting season.

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References

Ayob, A. M. 1979. The economics and adoption of the combine harvester in the Muda region of Malaysia. In *Workshop on the Consequences of Small Rice Farm Mechanization*, 1-31. Los Banos, Laguna, Philippines, 1-4 October.

Bowers, W., and D. R. Hunt. 1970. Application of mathematical formulas to repair cost data. *Transactions of the ASABE*, 13(6): 806–809.

Buckmaster, R D. 2003. Benchmarking tractor costs. *Applied Engineering in Agriculture*, 19(2): 151–154.

Calcante, A., L. Fontanini, and F. Mazzetto. 2013a. Repair and maintenance costs of 4WD tractors in Northern Italy. *Transactions of the ASABE,* 56(2): 355–362.

Calcante, A., L. Fontatnini, and F. Mazzetto. 2013b. Coefficients of repair and maintenance costs of self-propelled combine harvesters in Italy. *Agricultural Engineering International: CIGR Journal*, 15(3): 141–147.

Charles, Z., and K. K. Kirst-Ashman. 2016. *Understanding Human Behavior and the Social Environment.* Singapore: Cengage Learning.

Department of Agriculture (DOA), Peninsular Malaysia. 2015. Paddy production survey report Malaysia main season 2013/2014. Peninsular Malaysia: DOA.

Department of Agriculture (DOA), Peninsular Malaysia.2014. Paddy statistics of Malaysia 2014. Peninsular Malaysia: DOA.

Donnelly, M. 2015. Past Experience the Most Important Factor in Farm Machinery Purchases. AgriLand Website. Available at: http://www.agriland.ie/farming-news/past-experience-the-most-important-factor-in-farm-machinery-purchases/#. Accessed 16 December 2015.

FAOSTAT. 2016. Machinery: Malaysia's import quantity in year 2005-2009 (combine harvester-thresher). Available at: http://faostat3.fao.org/download/I/RM/E. Accessed 17 August 2016.

Guadagni, M., and T. Fileccia. 2009. The Kyrgyz Republic: Farm Mechanization and Agricultural Productivity. Rome. Italy: FAO and World Bank.

Hussain, A. A. M., and W. I. W. Ismail. 1983. Use of combine harvester in Malaysia. *Agricultural Mechanization in Asia, Africa and Latin America*, 14(1): 53–54.

Khodabakhshian, R., and M. Shakeri. 2011. Prediction of repair and maintenance costs of farm tractors by using of preventive maintenance. *International Journal of Agriculture Science*, 3(1): 39–44.

Kin, Y. Y., S. S. Jamuar, and A. Yahya. 2011. Combine harvester instrumentation system for use in precision agriculture. *Instrumentation Science & Technology*, 39(4): 374–393.

Lavrakas, P. J. 2008. *Encyclopedia of Survey Research Methods*, Thousand Oaks, California, USA: SAGE Publications, Inc.

Lips, M. 2013. Repair and maintenance costs for nine agricultural machine types. *Transactions of the ASABE*, 56(4): 1299–1307.

Mazzetto, F., and A. Calcante. 2010. Come valutare i costi della manutenzione (How to evaluate maintenance costs). *Il Contoterzista,* 2010(3): 1–6.

Muda Agriculture Development Authority (MADA). 2016. Organization History; Unveiling the History of the Muda Agricultural Development Authority. Available at: http://www.mada.gov.my/en/corporate-information/history-of-establishment/. Accessed 29 November 2016.

Putri, R. E., A. Yahya, N. M. Adam, and S. A. Aziz. 2016. Performance evaluation of yield monitoring system for rice combine harvester in Selangor, Malaysia. *International Journal on Advanced Science Engineering Information Technology*, 6(1): 35–39.

Roy, S. K., K. Jusoff, W. I. W. Ismail, and D. Ahmad. 2003. Performance evaluation of a combine harvester in Malaysian paddy field. *Agricultural Mechanization in Asia, Africa and Latin America,* 4(34): 38–44.

Samsudin, S. N., D. E. Pebrian, and A. J. Wan. 2017. Farm machinery repair costs: a case study at oil palm plantations in Malaysia, *International Journal of Agricultural Resources, Governance and Ecology*, 13(4): 391–403.

Siemens, J., W. Bowers, and R. G. Holmes. 2008. *Machinery Management.* Illinois, USA: Deere & Company.

Ward, S. M., P. B. McNulty, and M. B. Cunney. 1985. Repair costs of 2 and 4 WD tractors. *Transactions of the ASAE*, 28(4): 1074–1076.