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Introduction of Innovative Equipment in Mining: Impact on Productivity

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ABSTRACT

In this era of increased competition and rapid change, mining companies must remain attentive to all opportunities to gain an advantage over competitors. Acquisition of innovative equipment is often viewed as a way of decreasing operating costs, for example, by increasing machinery reliability. The objective of this paper is to examine the impact of new equipment on productivity in underground mining. Ten projects were examined using three indicators: the cost per meter drilled, the cost per hour of use and the equipment availability ratio. The results clearly show that the introduction of new equipment with technological innovations does not necessarily improve productivity. In some cases, performance indicators even dropped. We suggest that future research should focus on identifying the mechanisms and conditions that ensure the increases in productivity following the introduction of the latest innovations in mining equipment. Successful introductions of such equipment likely depend on the conditions surrounding it.

KEYWORDS

Innovation Equipment; Mining Equipment; Productivity; Mines

1. Introduction

The opening of new markets for metals and minerals represents opportunities for buyers and investors. In contrast, for existing producers and sellers, it means new competitors. These companies must learn to navigate in markets in which increasing numbers of players are trying to differentiate themselves. Compounding this challenge is rapid technological progress making communication and dissemination of strategic information easier than ever before.

Given the enormous costs associated with the development and the exploitation of a mine, mining companies must attract investors, who of course seek a competitive return on their investment. For a mine in operation, profitability depends on metal prices, ore grade, production, and operating costs. Metal prices vary with the mood of the markets, adding uncertainty and volatility. Profits could be made more secure with futures contracts, but this would repel the speculating investor. Mining companies of course have no control over ore grade, only over the decision to extract ore of a given grade. In contrast, production and operating costs are elements over which mining companies have definite control. Decisions in these areas are therefore critical for survival in a highly competitive environment in which numerous companies offer practically identical final products at the same prices.

In order to increase production and lower operating costs, one of the preferred solutions in the mining industry is to introduce innovative equipment [1-4]. For reasons of time and cost of development, most mining companies prefer to buy equipment directly from the manufacturer [5]. However, it is not uncommon for them to modify the equipment [6], or even to custom-design it in order to meet specific needs [7].

2. Problem

The acquisition of new equipment with novel technologies such as partial automation often promises significant gains to buyers. Companies considering the purchase of new equipment seek improvements in terms of availability ratio and reduced running-in costs [6,8]. However, several studies point out negative effects associated with the introduction of new technologies, among others poor operator acceptance [9], longer than expected adaptation periods due to inadequate training [9-15], skill deficiencies [9,10,13], over-reliance on the technology [9], and characteristics or functions differing from those of standard equipment [9,13].

The latest equipment often offers more options and features and hence more controls and commands for the operator to learn and understand. As a result, introducing new equipment is not necessarily synonymous with gain, even on the long term. There is often a trade-off between the gains provided by an innovation and the costs associated with its implementation and use. More specialized equipment with totally new functions might require a longer period of training and adaptation. The benefits generated by the new equipment must outweigh the costs of the additional training and the running-in period. The present article is focused on these particular aspects of introducing innovative equipment in the mining industries.

3. Methodology

In this study, we measured the impact that ten projects involving the introduction of innovative equipment had on the productivity of a North American underground goldmine, using three indicators, namely unit cost per meter drilled, unit cost per hour of use and the equipment availability ratio. Measurements were conducted over the 12-month period following each technological introduction in order to eliminate potential biases due to variations between different periods of the year [16]. For each project, we compared the productivity measured to that achieved using the corresponding older technology over the preceding 12-month period. Since the advent of partly automated equipment has spread primarily since the beginning of the 21st century [17], we limited our research to projects undertaken since this date. The ten equipment-upgrading projects examined in our study were carried out between 2005 and 2011.

3.1. Equipment Introduction Projects

Table 1. Summary of the ten equipment-upgrading projects under study.

Project	Category/type of equipment	Number of units	
		Innovative[1]	Standard[2]
1	Bolter/semi-automated	1	7
1.5	Bolter/semi-automated	1	2
2	Bolter/new generation	2	2
3	Long-hole drill/new generation	1	1
4	Truck/30 ton	3	10
5	Truck/50 ton	2	3
6	LHD/new generation	2	6
7	LHD/cab + air conditioning	6	4
8	Tractor/new generation	11	9
9	Tractor/different model	9	4
10	Scissor lift/new generation	2	8

[1]Introduced within 12 months of the first introduction of this type of equipment. [2]Included in the group used to measure productivity before the introduction of the new technology.

Table 1 below summarizes the ten projects under study. Project 1 involved the introduction in 2010 of an innovative bolting machine, used to install the mesh that stabilizes the field being mined. Costing $1 million, this machine (provided by manufacturer A) is fitted with two arms, directed from the cab by a seated operator using a joystick. Before the arrival of this equipment, the company used two different groups of bolting machines provided by manufacturer B, namely the standard groups in projects 1 and 1.5, which included respectively seven and two machines. We compared the performance of the innovative group to those of both standard groups. For the comparison of project 1.5, we should note that there is less than two years between the implementation of innovative group and the implementation of standard group.

Project 2 involved the deployment of two new-generation bolting machines obtained from manufacturer B, introduced in 2009 at a unit cost of nearly $900,000. The basis of comparison was a group of two machines of the same model, but manufactured more than 12 years earlier. The new machines were therefore designated as innovative.

Project 3 involved the introduction in 2010 of a long-hole drill obtained from manufacturer A and costing nearly $1.1 million. The basis of comparison was a drill obtained from manufacturer C and dating back to early 1990; nearly twenty years and numerous features thus separated the two pieces of equipment.

Project 4 was the introduction in 2010 of a fleet of three 30-ton trucks obtained from manufacturer D to replace some of the ten 50-ton trucks obtained from manufacturer A. The unit cost of the new trucks was $800,000. Dissatisfied with the performance of the 50-ton trucks because of their bulkiness, the company directors opted for new trucks with a smaller load capacity.

Project 5 was the introduction in 2005 of two 50-ton trucks purchased from manufacturer A for just over $1 million each. The company had been using 30-ton trucks, also from manufacturer A. The company wished to reduce vehicle traffic in the galleries by increasing truck loading capacity. The basis of comparison was a group of three older trucks.

Project 6 involved regrouping two 8-yard load-haul-dump (LHD) vehicles introduced in 2009. The unit cost of these machines was just under $1 million. Both new and old were obtained from manufacturer A, but are of different generations.

Project 7 involved introducing in 2007 six new 8-yard LHDs purchased from manufacturer A at a cost of over $850,000 each. These came with cab and air-conditioning, both lacking in the previously used machines (also from manufacturer A). The basis of comparison was a group of four of the older 8-yard LHDs.

Project 8 involved introducing in 2010 11 new tractors purchased from manufacturer E for underground use at a unit cost of $55,000. Used by supervisors, these tractors are designed specifically for mining. The chosen model is reputed to require less maintenance, which was the principal factor motivating the purchase. The innovative group was compared to a group of nine tractors of the same model but of a previous generation.

Project 9 involved introducing in 2008 nine tractors purchased from manufacturer E at a unit cost of $50,000. These replaced a group of four older tractors from the same manufacturer but of a model providing a lower loading capacity (in kg and persons) and less power (HP).

Project 10 involved regrouping two new scissor-lifts purchased from manufacturer B at a unit cost of more than $360,000 and introduced in 2010. The new platforms were chosen for their increased speed and for technical improvements such as opening on the side. The basis of comparison was a group of eight scissor lifts obtained from manufacturer F.

3.2. Performance Indicators

Having identified the vehicles forming the innovative and standard equipment groups for each project, we searched the mining company databases for information relating to the indicators studied. In order to measure the unit cost per meter drilled, we considered the expenditure incurred each month, in association with the use of the innovative equipment during the 12-month period following the first implementation, and with the use (and repair) of the standard equipment during the 12-month period precedent the first implementation of innovative equipment. The total cost thus calculated per group was divided by the number of meters drilled by all of the vehicles belonging to that group. These data were available for projects 1, 1.5, 2 and 3.

Total hours of use were also determined for the 12-month periods. These data, and hence the unit cost per hour of equipment use, were available for both groups for all ten projects.

In the case of equipment availability ratio, only one project could not be taken into account. Project 5 was the oldest project included in the study, and the company did not yet record availability at the time. This indicator represents equipment reliability, that is, the percentage of time that a group of vehicles was not in maintenance or repair, and hence in use or available for use. As was the case for the first two indicators, availability was calculated on the basis of 12 months.

4. Results

A descriptive comparison of performance based on the applicable indicator is provided below for each project. Statistical analysis (independent T-tests) was used to determine whether or not the innovative equipment provided any significant improvement over the standard (older) equipment in terms of performance as defined. The T-test results are valid if it is shown that the data are distributed normally in both of the compared groups [18]. The Shapiro-Wilk tests for normality of distribution are shown in Appendix I, and for 47 of the 50 data sets the normality was accepted. Based on these tests, our interpretations are reliable. Finally, the Fisher test for equality of the variances for the two groups indicated which type of T-test (*i.e.* for equal variances or for unequal variances) to use for each project comparison. The Fisher test results are shown in Appendix II.

4.1. Unit Cost Per Meter Drilled

Table 2 below shows the comparisons for the indicator of unit cost per meter drilled, based on the aggregate costs (for all the vehicles in the group) divided by the aggregate number of meters drilled, for the same 12-month period. The results show that the innovation (new, semi-automated bolting machine) provided an improvement of less than 7% in terms of this indicator in project 1, and increased drilling costs by more than 40% in project 1.5. With its many new features, the new machinery presented a challenge to the operators, which required longer break-in and adaptation periods than anticipated. Overall, the new bolting machinery, at a cost of $1 million per unit, increased drilling costs during the first year of use. However, in projects 2 and 3, the innovative groups yielded substantial reductions of the unit cost per meter drilled. In both projects, the cost per meter was reduced by at least 50%. In the case of project 2 (52.6%), this represented an overall annual saving of $577,567 and an expected payback period of 3.06 years for the initial investment of $1.8 million for the two new machines. This would be considered a relatively short period of time in business financing circles [19]. The corresponding period was 3.99 years for project 3, and nearly 71 years for project 1. Based on project 1, the investment was certainly not worth the cost if finances alone are considered.

Table 3 below summarizes the results of T-tests performed in order to determine whether or not the improvements in cost per meter drilled using the innovative machinery were significant, based on the monthly measurements. The criterion for rejecting the null hypothesis (*i.e.* that there is no significant difference) was a p-value of less than 0.05, meaning "the probability that the difference observed is due to chance is less than 5%" [18]. The results of projects 1 and 1.5 show that the new bolters did not improve to any significant degree the cost per meter drilled. The corresponding p-values obtained for projects 2 and 3 were less than 0.05, indicating that the innovative machinery provided significant improvement in unit cost per meter drilled. These results consolidate the conclusions drawn from the payback periods.

Table 2. Comparison of innovative and standard mining equipment in terms of unit cost per meter drilled.

Group	Project			
	1 (bolters)	1.5 (bolters)	2 (bolters)	3 (drills)
Innovative ($/m)	4.89	4.89	3.12	4.49
Standard ($/m)	5.23	3.46	6.58	11.23
Improvement (%)	6.5	−41.4	52.6	60.0

Table 3. T-tests for the effect of innovative equipment on the unit cost per meter drilled.

Statistic	Project			
	1 (bolters)	1.5 (bolters)	2 (bolters)	3 (drills)
T-value	0.2312	1.7321	−2.414	−2.704
P-value	0.5901	0.9514	0.013	0.010

4.2. Unit Cost Per Hour of Use

Table 4 shows the comparisons of innovative and standard machinery for the indicator of unit cost per hour of use, aggregated over 12 months. The results show that the innovations improved performance, based on this indicator. The vehicles in the innovative groups were less likely than the others to require repair, which is not surprising, given the number of years for which the latter machines had been in service. The cost of use was reduced by more than 50% in projects 2, 3, 4, 9 and 10. However, the improvement was relatively small (less than 20%) in other cases, in particular projects 1.5, 5 and 6, suggesting a low return on investment. The payback period for the introduction of the two LHDs in project 6 (price tag $1 million each) is more than 41 years. In the case of project 5, involving the introduction of two 50-ton trucks, the payback period is over 200 years!

Table 5 below summarizes the results of T-tests performed to determine whether or not the equipment upgrade projects brought statistically significant improvements in terms of cost per hour of use, based on all monthly measurements. Except for projects 1.5, 5 and 6, the improvements were significant. However, results obtained for projects 5 and 7 must be considered with

Table 4. Comparison of innovative and standard mining equipment in terms of unit cost per hour of use.

Group	Project										
	1	1.5	2	3	4	5	6	7	8	9	10
	Bolters			Drills	Trucks		LHDs		Tractors		Sc. lifts
Innovative ($/h)	69.33	69.33	77.59	75.69	31.36	53.61	66.65	68.41	12.39	13.36	37.68
Standard ($/h)	135.14	86.52	164.69	230.87	82.37	55.62	80.10	120.24	16.26	58.35	93.79
Improvement (%)	48.7	19.9	52.9	67.2	61.9	3.6	16.8	43.1	23.8	77.1	59.8

Table 5. T-tests for the effect of innovation on mining equipment unit cost per hour of use.

Statistic	Project										
	1	1.5	2	3	4	5	6	7	8	9	10
	Bolters			Drills	Trucks		LHDs		Tractors		Sc. Lifts
T-value	−4.334	−0.946	−2.106	−3.401	−5.675	−1.689	−0.892	-1.823	−2.626	−3.271	−2.714
P-value	0.000	0.179	0.023	0.003	0.000	0.056	0.191	0.045	0.008	0.009	0.007

caution, since the data did not pass the test for normality of distribution (see Appendix I).

Although these results suggest that the introductions of innovative equipment are beneficial in terms of unit cost per hour, this conclusion needs to be interpreted with caution. The indicator is essentially comparing new and old machinery in terms of costs for repair and maintenance, unlike the unit cost per meter drilled, which gives information on the adaptation period, for example by comparing the number of meters drilled for a fleet of machines.

4.3. Availability (Reliability)

Table 6 presents the comparison of innovative and standards groups in terms of equipment availability ratio, aggregated over the 12-month period. These results show a decline in availability for two projects (1.5 and 6) an increase exceeding 8% for one project (2), and increases of 3% - 8% for the others. These results may seem surprising since new equipment is being compared to equipment that had been in use for several years. Another interesting result was obtained for the vehicles equipped with cab and air-conditioning (project 7). There is a perception in the industry that the reliability of air-conditioned mining vehicles is lower. In the present study, this type of vehicle provided the second best improvement in terms of availability.

Table 7 below summarizes the results of T-tests performed on the basis of the monthly measurements in order to determine if the equipment-upgrading projects provided statistically significant improvement in availability. Improvement was significant for projects 2, 4, 7, 8 and 10. This is to say that half of the projects (1, 1.5, 3, 6 and 9) did not lead to improved equipment availability. This result is interesting because it included the three equipment categories for which more than one upgrading project was undertaken. Only one new group of bolters provided significant improvement (project 2) and the same was observed for LHDs (project 7) and tractors (project 8). For these types of equipment at least, upgrading may or may not lead to improved availability. We note here that based on the T-test, the improvement in the reliability of vehicles equipped with cab and air-conditioning was unequivocal (Table 7).

The T-test result for project 10 must be interpreted with caution since the data did not pass the test for normality of distribution (see Appendix I).

4. Discussion

Measuring the performance indicators over a 12-month period gives our results a certain internal validity. Other indicators could be used, such as tonnage/miner/year [5, 20]. However, we chose three simple indicators recognized in the field [6,8] in order to facilitate duplication of our method for future researches. Other companies can easily use these indicators to measure the performance of their equipment introduction projects, although comparison of their results with ours would be of limited value, given the particularities of each environment.

Although our focus was productivity, the motivation

Table 6. Comparison of innovative and standard mining equipment in terms of availability ratio.

Group	Project										
	1	1.5	2	3	4	5	6	7	8	9	10
		Bolters		Drills	Trucks		LHDs		Tractors		Sc. lifts
	Availability (%)										
Innovative	78.5	78.5	85.3	78.5	87.3	N/A	82.1	84.7	97.9	93.0	96.2
Standard	77.0	85.8	71.0	71.3	80.8	N/A	83.2	77.0	92.7	89.9	90.5
Improvement	1.6	−7.3	14.4	7.2	6.4	N/A	−1.1	7.7	5.2	3.1	5.7

N/A: not applicable.

Table 7. T-tests for the effect of innovation on equipment availability in mining.

Statistic	Project										
	1	1.5	2	3	4	5	6	7	8	9	10
		Bolters		Drills	Trucks		LHDs		Tractors		Sc. Lifts
T-value	0.462	−1.943	4.999	1.386	3.782	N/A	−0.520	3.467	6.328	1.652	2.829
P-value	0.326	0.963	0.000	0.093	0.001	N/A	0.695	0.001	0.000	0.058	0.005

for introducing technological innovations may be broader. Improvements in working conditions may be sought. This appears to have been the particular aim of projects 1.5 and 7. The semi-automated bolting machine in project 1.5 eliminates certain operations that were once manual, such as raising and moving mesh. The LHD with cab and air conditioning in project 7 offers operators a safer and more comfortable working environment. As our results show, these projects arrived at quite different results, namely decreased productivity in terms of $/meter and availability ratio in the case of the bolting machine, versus benefits in terms of cost per hour of use and availability ratio in the case of the LHD. This comparison highlights the dilemma of decision makers, since the impact of innovation on productivity and on OHS is inconsistent. Complicating the decision is the current shortage of skilled manpower in the mining sector. Working conditions may attract some workers, while performance bonuses may be more interesting to others [9,15,21,22]. The choice often involves a trade-off, for example between a level of risk and the speed of a LHD.

Our results challenge widespread belief that bigger is better, as claimed by various authors [5,23]. As reported by another researcher [8], smaller equipment may match or even exceed the performance of larger equipment. We noted such a result in the case of project 4, which compared the introduction of 30-ton trucks to the existing 50-ton truck fleet. In terms of both cost per hour of use and availability ratio, the smaller equipment was shown to bring a significant increase in performance. Smaller may be better.

Although brand-new machines were compared to those that had been in use for several years, only half of the equipment introduction projects led to improved availability ratio. Based on the T-tests, fewer than half of the projects led to significant improvement of the performance indicators studied: only one of the three bolter projects, one of the two trucks projects, one of the two LHD projects and one of the two tractor projects. Our study provides no basis for generalizing about any machine type.

Since our results show that the acquisition of innovative mining equipment does not automatically bring gains in productivity, we suggest that future research focus on identifying the mechanisms and conditions that are involved when the introduction of innovation does generate an increase of the productivity. What are the conditions in common among the projects that lead to an increase in productivity? Based on our interviews and observations in the field, it appears that ergonomics are sometimes neglected when designing new machinery. Other researchers have raised this concern [13,15]. Furthermore, a variety of human factors may also have an influence on the success of implementation of novel machinery technology [9,10,24], but these remain to be measured.

Equipment automation warrants special consideration. As Bill Gates stated, “The first rule of any technology used in a business is that automation applied to an efficient operation will magnify the efficiency. The second is that automation applied to an inefficient operation will magnify the inefficiency”. The second rule appears to apply to the semi-automated bolter. Fully automated machinery has yet to prove its worth, although some researchers are working on it [9], and North American mining companies continue to prefer semi-automated machinery. Several issues, including maintenance, need to be resolved in order to maximize the benefits of automation [25]. The availability ratio of the bolter in project 1 reflects this challenge, and with results like these, the rarity of automated underground mining equipment is not surprising. Automation has been spreading in North American mining since 2010, but less than on other continents. Only three sites use automated vehicles: Elko (Nevada), Helmo Camp and Kidd Creek (Ontario). In Canada, human intervention will remain indispensable, according to several mining companies. We do not expect to see a fully automated mine working efficiently any time soon. The LHD is the vehicle closest to being operated from the surface, but this practice has yet to prove its worth [25]. Other types of equipment such as bolters and jumbos are not even close to becoming fully automated. Human workers will continue to activate and drive bolters and drills for the foreseeable future, primarily because bolting is so crucial to the structural stability of galleries and hence the safety of miners, and because drilling is the most specialized task underground, as well as the most prestigious from a professional perspective, and human input adds value to the drilling process.

5. Conclusion

The main contribution of our study is a demonstration based on objective data that the acquisition of innovative equipment in underground mining does not automatically bring gains in productivity. Our results show that the new equipment may perform less efficiently than the old equipment in spite of the very high cost of its purchase. Finally, our findings suggest the importance of identifying the mechanisms and conditions which allow an increase in productivity following the introduction of innovative mining equipment.

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Appendix I. Shapiro-Wilk Normality Tests

	Innovative groups															
	Bolters									**Drills**			**Trucks**			
	Project 1			**Project 1.5**			**Project 2**			**Project 3**			**Project 4**		**Project 5**	
	$/M	$/H	Avail	$/M	$/H	Avail	$/M	$/H	Avail	$/M	$/H	Avail	$/H	Avail	$/H	Avail
Shapiro-Wilk value	0.940	0.969	0.937	0.940	0.969	0.937	0.888	0.876	0.927	0.925	0.963	0.906	0.948	0.940	0.963	N/A
P-value	0.504	0.901	0.460	0.504	0.901	0.460	0.135	0.079	0.350	0.362	0.805	0.188	0.614	0.548	0.813	
	LHDs						**Tractors**						**Scissor Lifts**			
	Project 6			**Project 7**			**Project 8**			**Project 9**			**Project 10**			
	$/H	Avail		$/H	Avail		$/H	Avail		$/H	Avail		$/H	Avail		
Shapiro-Wilk value	0.972	0.980		0.938	0.924		0.907	0.919		0.948	0.936		0.912	0.683		
P-value	0.932	0.983		0.557	0.325		0.197	0.279		0.670	0.443		0.226	0.001		
	Standard groups															
	Bolters									**Drills**			**Trucks**			
	Project 2			**Project 3**			**Project 4**			**Project 2**			**Project 4**		**Project 5**	
	$/M	$/H	Avail	$/M	$/H	Avail	$/M	$/H	Avail	$/M	$/H	Avail	$/H	Avail	$/H	Avail
Shapiro-Wilk value	0.943	0.948	0.920	0.903	0.917	0.943	0.928	0.869	0.947	0.865	0.962	0.879	0.911	0.975	0.842	N/A
P-value	0.538	0.613	0.285	0.172	0.265	0.543	0.386	0.064	0.591	0.056	0.798	0.084	0.253	0.958	0.029	
	LHDs						**Tractors**						**Scissor Lifts**			
	Project 6			**Project 7**			**Project 8**			**Project 9**			**Project 10**			
	$/H	Avail		$/H	Avail		$/H	Avail		$/H	Avail		$/H	Avail		
Shapiro-Wilk value	0.914	0.965		0.765	0.931		0.902	0.898		0.839	0.823		0.918	0.869		
P-value	0.239	0.848		0.018	0.523		0.169	0.149		0.098	0.069		0.300	0.064		

Appendix II. Fisher Tests for the Equality of Variances.

	Bolters						Drills					
	Project 1			Project 1.5			Project 2			Project 3		
	$/M	$/H	Avail	$/M	$/H	Avail	$/M	$/H	Avail	$/M	$/H	Avail
F value	3.0462	0.7959	12.0170	1.1118	0.3230	9.3865	0.5517	0.4249	0.2210	0.0475	0.1217	0.2070
Reject H0 if:												
F >	2.818	2.818	2.818	2.818	2.818	2.818	2.978	2.818	2.818	2.854	2.978	2.818
F <	0.3549	0.3549	0.3549	0.3549	0.3549	0.3549	0.3358	0.3549	0.3549	0.3398	0.3358	0.3549
Decision	H1	H0	H1	H0	H1	H1	H0	H0	H1	H1	H1	H1
Variance	Unequal	Pooled	Unequal	Pooled	Unequal	Unequal	Pooled	Pooled	Unequal	Unequal	Unequal	Unequal
	Trucks						LHDs					
	Project 4			Project 5			Project 6			Project 7		
	$/H	Avail		$/H	Avail		$/H	Avail		$/H	Avail	
F value	0.5887	2.9130		0.2165			2.4144	3.0881		0.5467	1.1808	
Reject H0 if:												
F >	2.978	2.896		2.854	N/A		2.818	2.818		4.147	3.603	
F <	0.3358	0.3224		0.3398			0.3549	0.3549		0.2793	0.3320	
Decision	H0	H1		H1			H0	H1		H0	H0	
Variance	Pooled	Unequal		Unequal			Pooled	Unequal		Pooled	Pooled	
	Tractors						Scissor Lifts					
	Project 8			Project 9			Project 10					
	$/H	Avail		$/H	Avail		$/H	Avail				
F stat	0.7810	0.1655		0.0032	0.4858		0.6856	0.4702				
Reject H0 if:												
F >	2.818	2.818		4.147	4.027		2.943	2.818				
F <	0.3549	0.3549		0.2793	0.3231		0.3504	0.3549				
Decision	H0	H1		H1	H0		H0	H0				
Variance	Pooled	Unequal		Unequal	Pooled		Pooled	Pooled				