PRODUCTIVE EFFICIENCY OF MALAYSIAN CONSTRUCTION SECTOR

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Abstract

The productivity level is viewed as a basic index of gauging the health of an individual enterprise, an industry, or an economy. It forms the basis for improvements in real incomes and welfare. A sound productive measurement is crucial for a productive unit to manage its performance effectively. A number of indicators have been developed to measure the productivity level. These indicators usually measure some or all of the inputs and outputs of the industry; many of them are inaccurate, reward the wrong behaviour, lack predictive power; do not captures key changes until it is too late. Hence, they failed to be a satisfactory measure of performance efficiency. The technique of measuring productive efficiency originated by Farrell takes account of all inputs to evaluate the productive efficiency of a productive unit in relation to the most efficient frontier. The Farrell method is used to analyse the performance of Malaysian construction sector in attempt to explain the performance of the sub-sectors. The application of this study is it provides an alternative means to assess the competitiveness of a firm.

Keywords: productivity, productive efficiency, construction sector.

Introduction

Productivity is the engine of economic both for a country and for an individual organization (Hope and Hope 1997). Productivity efficiency is a survival condition in a competitive environment. In a nutshell, productivity growth involves getting more from what we have. Getting a bigger 'pot' of goods for everyone as a whole means increased output from a particular amount of resources or inputs. Therefore it needs to identify increased productivity rather than just an increase in size and output growth that can be 'explained' by input increases (Morrison 1998). The first issue to address for conceptualising, computing and interpreting such a measure is how to define and measure these outputs and inputs. The method originates from Farrell's (1957) seminal paper in measuring the productive efficiency is used to analyze the Malaysian construction industry. It is also use to compare the productive efficiency among the different firm sizes and types of work.

Productivity Measurement

Productivity is an overall conception which is difficult to express or to measure. It is sometimes expressed in terms of output from labour, or from services, or from capital invested. These partial expressions often do not give an accurate picture of the overall position. Although they are measurements of some or all of the inputs and outputs of the industry; but they failed to combine these measurements into any satisfactory measure of efficiency. Besides, the ratio is easy to compute if the unit uses a single input to produce a single output. But, in the real-world complexities the unit uses several inputs to produce several outputs. The outputs in the numerator must be aggregated in some economically sensible fashion, as must the inputs in the denominator, so that productivity remains the ratio of two scalars (Lovell 1993). Given the wide range of products and inputs we attempt to add 'apples and oranges' somehow, and the typical weight is the price. According to Morrison (1998), price distortion is the source of bias in the aggregate measures. The underlying issues to deal with when attempting to distinguish real-quantity measures are quality changes and the existence of appropriate prices. Lovell (1993) claims that *"even when all relevant outputs and inputs are included, there remains the difficulty that market prices may not exist, and if they do exist they may not provide an appropriate measure of usefulness"*.

Construction industry is heterogeneous and complex nature of its output; almost every project in construction is unique. It is exceedingly difficult to find a uniform measure of the quality of construction projects (Harrison 2007). With each new project there is a choice of construction materials and the way it will be constructed, particularly whether to use more labour or more plant and equipment.

In addition, there is a clear and distinct difference between production and productivity. It is quite possible to increase the actual volume of production and yet decrease productivity. Therefore, we should concerned not simply with increasing output, but with increasing output from the same or smaller use of our resources of all kinds, i.e. seeking higher productive efficiency (Currie 1980).

The normal productivity measurement assumes goods are homogenous, thus the quality aspect of productivity is buried and unmeasurable (Morrison 1998). Accounting ratio such as cost per employee is commonly used to evaluate the operational efficiency of a productive unit. An organization with a high ratio in comparison with those of other organization would be considered less efficient, but the higher ratio could result from a more complex mix of transactions. For example, a residential housing contractor would require more labours than civil engineering contractor which is using more machinery. The problem of using simple ratios is that the mix of outputs is not considered explicitly. The same criticism also can be made concerning the mix of inputs. For example, some residential contractor may use more off-site prefabrication components, and this use of off-site technology could affect the cost per employee (Haskell 2004).

Broad-based measures such as profitability or return on investment are highly relevant as overall performance measures, but they are not sufficient to evaluate the operating efficiency of a productive unit. For instance, one could not conclude that a profitable construction firm is necessarily efficient in its use of personnel and other inputs. A higher-than-average proportion of revenue-generating transactions could be the explanation rather than the cost-efficient use of resources (Haskell 2004).

Productive Efficiency

For a long time it was considered adequate to measure the average productivity of labour, and to use this as a measure of efficiency. This is a patently unsatisfactory measure, as it ignores all inputs save labour (Farrell 1957). Farrell's productive efficiency measurement hypothesized that efficiency could be dichotomizes into two subcomponents reflecting the physical efficiency of the input-output production transformation (the technical component) and the economic efficiency of optimal factor allocation (allocative efficiency) (Kopp 1981). The purely technical, or physical, component refers the ability to avoid waste by producing as much output as input usage allow, or by using as little input as output production allows. Thus the analysis of technical efficiency can have an output augmenting orientation or an input-conserving orientation. The allocative, or price, component refers to the ability to combine inputs and outputs in optimal proportions in light of prevailing prices (Fried 1993). A producer is technical efficiency if an increase in any output requires a reduction in at least one other output or an increase in at least one input and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output. Thus a technically inefficient producer could produce the same outputs with less of at least one input, or could use the same inputs to produce more of at least one output (Lovell 1993).

For illustration of Farrell's proposition, consider a construction firm employing two factors of production capital (K) and labour (L) to produce a single product (Q), under condition of constant return to scale. The assumption of constant returns permits all the relevant information to be presented in a simple 'isoquant' diagram. The relationship between inputs and outputs of these production units can be on a two-dimensional plane with the L/Q and K/Q as the X-axis and Y-axis respectively. L/Q and K/Q indicates the proportion of labour to output and capital to output respectively. A high ratio indicates high labor or capital intensive. In figure 1, the point P represents the inputs of the two factors that the firm is observed to use. Since there is no prior knowledge, SS' is estimated by joining the observed best practices regression curve. To complete the production frontier, two curve segments are projected from the observations that use the minimum amount of each input to infinity, i.e. two extra hypothetical observations represented by (0, ∞) and (∞, 0) that lie at the two end-points. The curve SS', then, will be taken as the estimate of the efficient isoquant. Each point on the isoquant SS' represents the quantity and mix of inputs used by a production unit to produce one unit of output. SS' represents the 'efficiency frontier' of the 'production possibility set' because it is not possible to reduce the value of inputs without increasing the other input if one is to stay on this isoquant. Technological progress over time is represented by the movement of the SS' towards the origin (Chau, Poon et al. 2005).

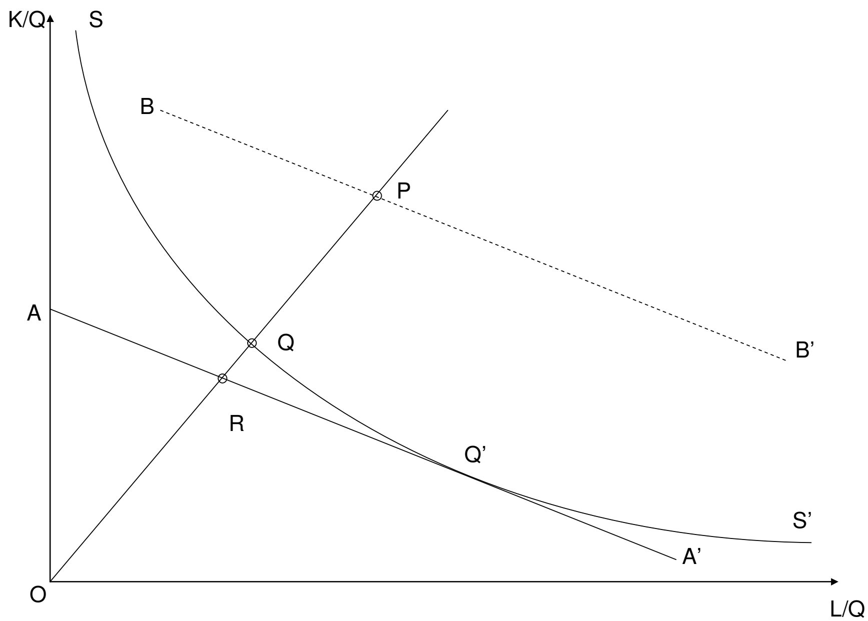

Figure 1 Relative productive efficiency

With these assumptions, the relative efficiency of any observation P can be evaluated by comparing the distance of P from the origin (OP) to a hypothetical observation Q on SS' that use the same input mix as P (OQ). It can be seen that Q produces the same output as P using a fraction OQ/OP as much of each factor. Farrell proposes OQ/OP as the technical efficiency (TE) of the firm P. It takes the value 100 per cent for a perfectly efficient firm, and will become indefinitely small if the amount of input per unit output becomes indefinitely large. Moreover, so long as SS' has a negative slope, an increase in the input per unit of one factor will, ceteris paribus, imply lower technical efficiency (Farrell 1957).

AA' in figure 1 has a slope equal to the ratio of the prices of the two factors. It represents an isocost line for which (x, y) pairs on this line yield the same total cost. Q' is the minimum total cost needed to produce the specified output since any parallel shift downward below Q' would yield a line that fails to intersect the production possibility set. Thus, intersection at Q' gives an input pair that minimizes the total cost of producing the specified output that the point Q' is therefore said to be 'allocatively' as well as 'technical' efficient.

Now consider the point R which is at the intersection of this cost line through Q' with the ray from the origin to P. We can also obtain a radial measure of overall efficiency from the ratio OR/OP. While keeping its technical efficiency constant at Q', its costs would be reduced by a factor OR/OQ, so long as factor prices did not change. OR/OQ is thus defined as 'price efficiency' but is now more commonly called 'allocative efficiency'(AE) of Q (Farrell 1957).

Finally, we can relate these three measures to each other by noticing that $\frac{OR}{OQ} \times \frac{OQ}{OP} = \frac{OR}{OP}$. Thus overall productive efficiency (PE) is a single index that combined physical (TE) and economic (AE) efficiency (Kopp 1981).

Productive Efficiency of Malaysian Construction Sector

Farrell's measurement of productive efficiency is used to evaluate the performance of the construction sector in Malaysia. The data for the analysis is obtained from the various issues of the Survey of Construction Industries, Malaysia.

The 'unit labour' and 'unit capital' are computed by the formulae, $\frac{\text{Number of employees}}{\text{Gross Output}}$ and $\frac{\text{Values of assets}}{\text{Gross Output}}$ respectively. In order to make comparisons over time, the current prices of values of assets and gross output are converted into constant 1990 price by deflating each component by consumer price index. Figure 2 is a scatter-plot of TE of Malaysian Construction Sector between years 1970 and 2004. The regression model of the isoquant, $y = 0.0012x^{-0.5786}$, represents the 'efficiency frontier' of the 'production possibility set'.

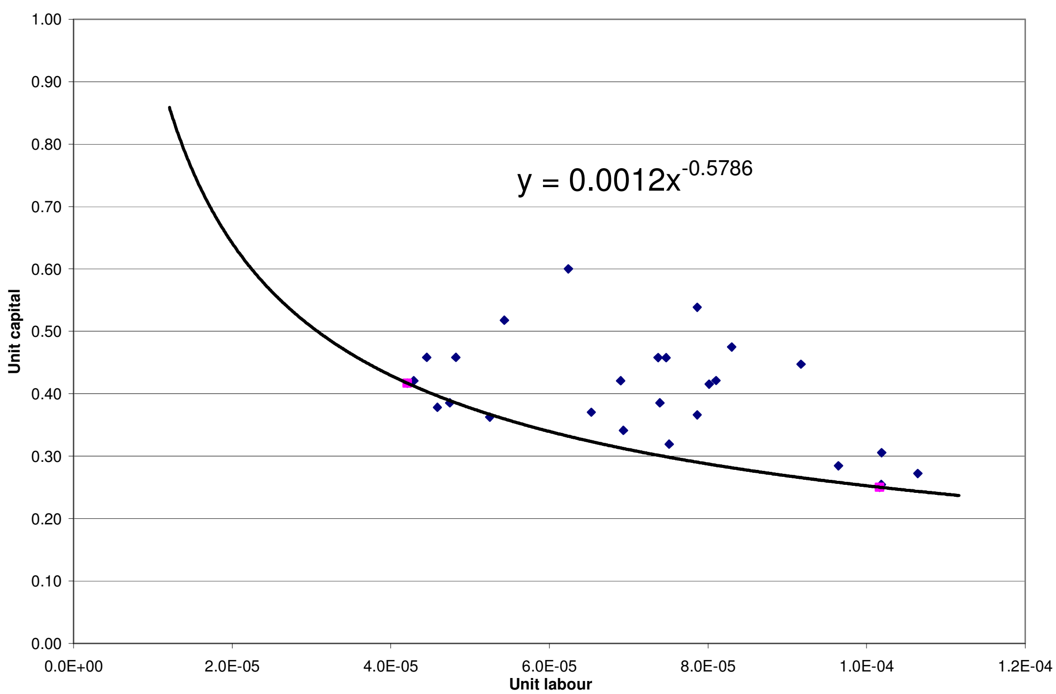

Figure 2 Regression Curve of Technical Efficiency of Malaysian Construction Sector (1970-2004)

Table 1 Technical Efficiency, Allocative Efficiency and Productive Efficiency of Malaysian Construction Sector (1970-2004)

Year	Technical Efficiency					Allocative Efficiency					Productive Efficiency				
	Civil engineering	Non-residential	Residential	Special trade	Total	Civil engineering	Non-residential	Residential	Special trade	Total	Civil engineering	Non-residential	Residential	Special trade	Total
1971	0.1585	0.9288	0.9492	0.9219	0.9197	0.0057	0.1513	0.2325	0.0427	0.0953	0.0009	0.1405	0.2207	0.0394	0.0876
1972	0.1586	0.9115	1.0043	0.8803	0.9754	0.0062	0.1362	0.2598	0.0536	0.0980	0.0010	0.1241	0.2609	0.0472	0.0956
1974	0.4319	1.0032	0.8412	0.7925	0.9269	0.0020	0.1593	0.2071	0.0467	0.0870	0.0008	0.1599	0.1742	0.0370	0.0807
1979	0.5542	0.7679	0.6499	0.7341	0.9868	0.0014	0.0843	0.1640	0.0374	0.0956	0.0008	0.0648	0.1066	0.0274	0.0944
1985	0.6738	0.7661	0.8683	0.7537	0.9446	0.0012	0.0720	0.2124	0.0336	0.0669	0.0008	0.0551	0.1844	0.0253	0.0632
1986	0.6710	0.7371	0.7522	0.6866	0.9332	0.0013	0.0698	0.1820	0.0292	0.0620	0.0009	0.0514	0.1369	0.0201	0.0578
1987	0.6522	0.6076	0.5610	0.6400	0.8519	0.0013	0.0649	0.1405	0.0270	0.0641	0.0009	0.0395	0.0788	0.0173	0.0546
1988	0.5739	0.6417	0.6970	0.6710	0.7810	0.0016	0.0673	0.1616	0.0295	0.0607	0.0009	0.0432	0.1127	0.0198	0.0474
1989	0.6513	0.7538	0.7719	0.6951	0.7092	0.0015	0.0795	0.2038	0.0319	0.0632	0.0010	0.0599	0.1573	0.0222	0.0448
1990	0.7111	0.7244	0.9100	0.8036	0.8438	0.0013	0.0676	0.2148	0.0337	0.0648	0.0009	0.0490	0.1955	0.0271	0.0546
1991	0.7556	0.9901	0.8926	0.8369	0.7571	0.0014	0.0921	0.1988	0.0354	0.0579	0.0010	0.0912	0.1774	0.0296	0.0438
1992	0.6484	1.0237	1.0250	0.8156	0.7536	0.0010	0.0866	0.2494	0.0316	0.0583	0.0006	0.0887	0.2556	0.0257	0.0439
1993	0.7908	0.9891	1.0196	0.8671	0.6673	0.0009	0.0768	0.2179	0.0319	0.0542	0.0007	0.0759	0.2222	0.0276	0.0362
1994	0.9161	1.0048	0.9583	0.8923	0.7085	0.0012	0.0782	0.1858	0.0300	0.0598	0.0011	0.0785	0.1780	0.0268	0.0424
1995	0.9676	0.9496	0.9091	0.9264	0.7711	0.0011	0.0648	0.1665	0.0283	0.0644	0.0011	0.0615	0.1513	0.0262	0.0497
1996	1.0190	1.0033	0.9730	0.9705	0.8182	0.0010	0.0687	0.1772	0.0266	0.0598	0.0011	0.0689	0.1724	0.0259	0.0489
1998	0.8840	0.9446	0.8063	0.8424	0.9053	0.0010	0.0688	0.1524	0.0231	0.0641	0.0009	0.0650	0.1229	0.0194	0.0580
2000	0.9676	0.9894	0.8439	0.8470	0.6783	0.0009	0.0698	0.1543	0.0208	0.0472	0.0009	0.0691	0.1302	0.0176	0.0320
2002	0.9872	0.8465	0.9303	0.8803	0.7834	0.0011	0.0623	0.1625	0.0205	0.0480	0.0011	0.0527	0.1512	0.0181	0.0376
2004	0.9536	0.9010	1.0043	0.9097	0.9943	0.0010	0.0617	0.1589	0.0213	0.0597	0.0010	0.0556	0.1595	0.0194	0.0593

Table 2 Labour Productivity, Capital Productivity and Capital Intensity of Malaysian Construction Sector (1970-2004)

Year	Labour Productivity					Capital Productivity					Capital Intensity				
	Civil engineering	Non-residential	Residential	Special trade	Total	Civil engineering	Non-residential	Residential	Special trade	Total	Civil engineering	Non-residential	Residential	Special trade	Total
1971	5.7062	21.6036	22.0605	31.8302	22563	1.9299	4.5893	4.0892	3.9060	8.8181	1.2456	1.6302	2.3037	3.0046	2559
1972	5.1547	22.0016	23.1168	33.6685	23085	2.1246	4.3214	4.4351	4.2198	9.2325	1.0971	1.8310	2.0972	2.2853	2500
1974	21.7268	20.7938	23.2948	30.8227	24379	1.6638	5.1242	3.5000	3.6322	8.2527	5.7657	1.4853	2.6282	2.5241	2954
1979	33.0790	25.6033	24.7843	32.1640	22980	1.5175	2.8661	2.4333	2.8679	9.3291	9.0845	3.5845	3.9216	3.5964	2463
1985	48.1886	32.4666	26.6789	37.5815	28639	1.5655	2.5334	3.4184	2.6228	6.7282	11.3050	5.0359	3.2417	4.6488	4257
1986	43.2355	32.4452	27.0177	37.7758	30425	1.8372	2.4014	2.8240	2.1712	6.1829	9.0850	5.2501	3.8819	5.7479	4921
1987	39.2788	30.4485	25.6432	36.9449	29298	1.7652	1.9221	1.9341	1.9116	6.2901	9.2261	5.7041	5.3623	6.5235	4658
1988	33.9075	31.6767	28.6607	36.9097	28608	1.8808	2.0708	2.5348	2.1546	5.5167	7.1509	5.3939	4.3800	5.5551	5186
1989	39.7828	32.3131	27.0589	37.5357	27341	2.0296	2.6151	3.0320	2.3379	5.6056	7.6475	4.4016	3.2704	5.0124	4877
1990	46.0748	36.9226	31.5569	40.9368	34052	1.8943	2.2886	3.5333	2.7407	6.5323	9.4225	5.7242	3.4171	4.8606	5213
1991	47.6079	37.8008	34.6911	42.2074	36140	2.1585	3.5640	3.3266	2.9153	5.8156	8.5854	3.9676	3.9905	4.6377	6214
1992	49.8925	38.9889	33.9812	43.5942	35144	0.9913	3.5312	4.0904	2.6287	5.7347	19.7370	4.4721	3.0798	5.5105	6128
1993	61.7089	42.7987	37.5552	45.1263	32858	1.2370	3.1869	3.8349	2.7759	4.7988	19.1432	5.4163	3.8543	5.5935	6847
1994	55.2909	44.7899	39.2273	49.5471	32535	2.3208	3.2127	3.4039	2.7100	5.6843	10.0746	5.5340	4.7892	6.2858	5724
1995	61.3758	50.3389	45.0495	54.0085	34105	2.3214	2.7356	3.0744	2.6947	6.5569	10.8313	7.4167	5.7686	6.9178	5201
1996	69.5384	53.6096	45.6324	58.1036	39074	2.3018	2.9547	3.3139	2.6756	6.4033	11.7365	6.9714	5.6167	7.7904	6102
1998	63.1592	49.1774	44.1536	56.1863	41123	1.7960	2.7971	2.6049	2.0954	7.2448	13.5156	6.8660	6.8610	9.7854	5676
2000	72.9773	54.0672	53.2087	64.8901	42240	1.7750	2.9570	2.7077	1.9318	4.3926	15.4835	6.6905	7.0421	11.8625	9616
2002	74.2922	50.7581	56.4571	71.1460	47985	2.2964	2.3984	3.0319	1.9764	5.0322	11.2858	7.7726	6.6384	12.2819	9536
2004	75.5990	60.0170	63.0476	71.7629	47516	2.0423	2.5101	3.2351	2.1056	6.8790	12.5984	8.1484	6.9388	11.4780	6907

Table 1 is the results of TE, AE and PE of the Malaysian Construction Sector and its output mix. The highest PE and AE are recorded in 1972 and highest TE at 1973. The 'oil crisis' happened in year 1973 which has caused recession in the mid of 1970s. Malaysia was experienced suppressive of economic activity too. The high PE indicates that the productive efficiency is improved at the early phase of recession and it will decline after that. Most of the company will keep high work intensity and capacity utilisation rate at the beginning of downturn as a tightening cost control measures. However, this measures could not be sustained because of over capacity will take effects soon when there are no new projects secured.

All the three efficiency indices are recorded lowest in 2000. Although Malaysia is recovering from 1997 Asian Financial Crisis, but the surplus construction capacity in 1990s was not fully absorbed by the market. Thus, the redundancies of capacity caused decline in productivity.

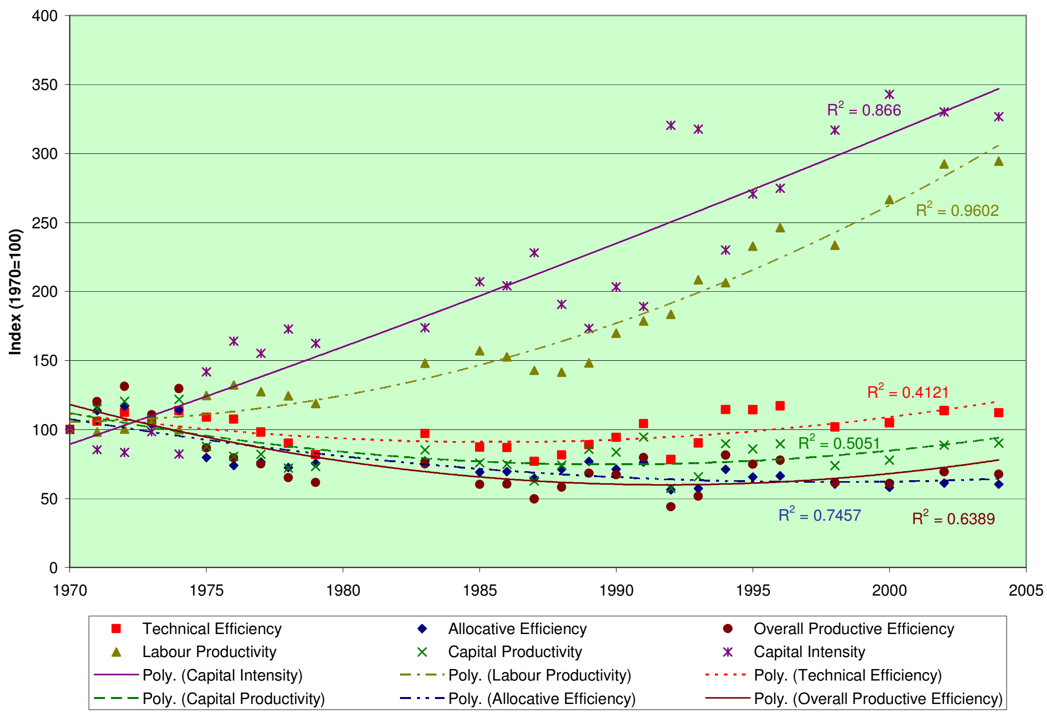

Figure 3 Productive Efficiency and Productivity Indicators of Malaysian Construction Sector (1970-2004)

Figure 3 shows that TE had recovered in 1986, but the declined AE slows down the recovery of PE. Table 2 further reveals that there is a strong positive relationship between PE and capital productivity (r = 0.990, ρ<.000). The PE is negatively correlated with labour productivity (r = 0.457, ρ<.000). There is no significant improvement in the capital productivity although there is vast increase in the capital intensity over the period of this study. Capital productivity is the measure of how well physical capital is used in providing goods and services, i.e. output/total assets. Slack (2002) break the ratio into three ratios, 'output/capacity', 'fixed assets/total assets' and 'capacity/fixed assets'. 'Output/capacity' is the utilisation of the operation. To improve capital productivity, utilisation needs to be as close to 1 as possible. This can be achieved either by generating demand to match the capacity or the operation must develop an ability to adjust its capacity to match demand. 'Fixed assets/total assets' is a ratio governed by the working capital requirements of the business. The smaller the working capital required by the operation, the closer fixed assets is to total assets. Working capital minimisation is a matter of reducing the inventories in its supply network. 'Capacity/fixed assts' is a measure of how much the operation needs to spend in order to acquire, or develop, its capacity. It is largely a function of organisation's process technology decisions. An operation that achieves the required capacity level without needing large amounts of capital expenditure will have a better ratio. The skill of the operation's designers and technologists will determine this (Slack and Lewis 2002).

Table 3 Correlations of Productive Efficiency and Productivity Indicators

Productivity Indicators	Pearson Correlation	Sig. (2 tailed)
Technical Efficiency	.620**	.001
Allocative Efficiency	.935**	.000
Labour Productivity	-.457*	.017
Capital Productivity	.990**	.000
Capital Intensity	-.733**	.000
K/L	-.864**	.000

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

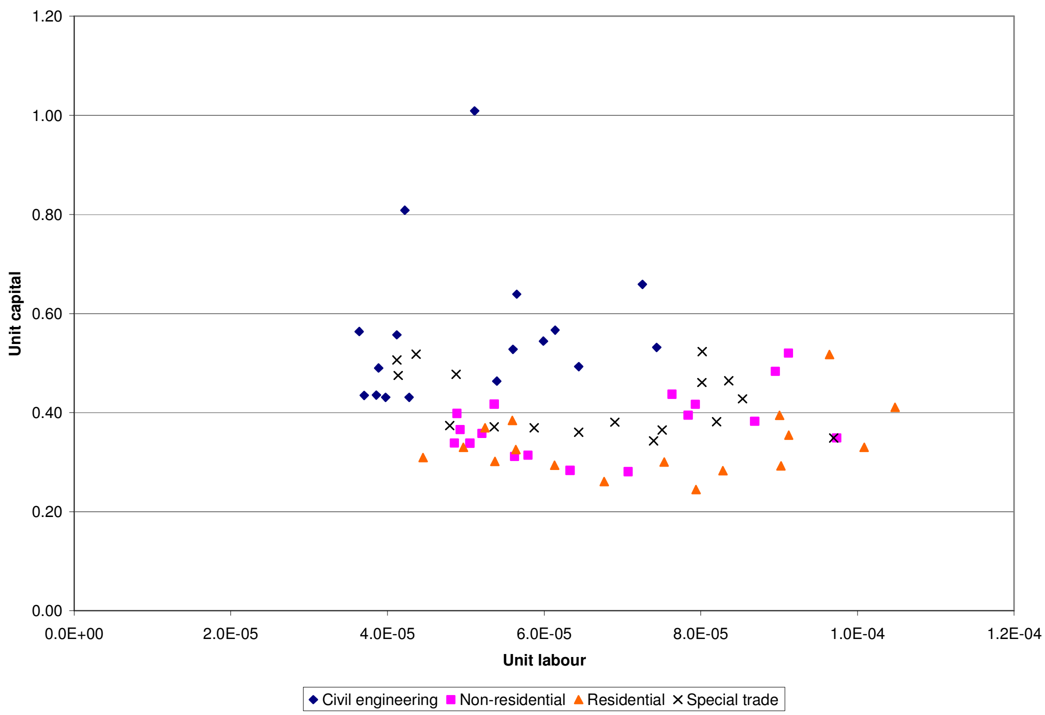

Figure 4 Technical Efficiency of Construction Output Mix

Table 4: Means and One-way ANOVA comparing Productive Efficiency and Productivity Indicators on Construction Output Mix

Type of work	N	Technical efficiency	Allocative Efficiency	Productivity Efficiency	Labour productivity	Capital productivity	Capital Intensity
Civil engineering	20	0.7063	0.0017	0.0092	18.3160	1.8730	10.2025
Non-residential	20	0.8742	0.0841	0.0747	14.4655	3.0290	5.1645
Residential	20	0.8684	0.1901	0.1674	13.7890	3.2165	4.4540
Special trades	20	0.8184	0.0317	0.0260	15.3460	2.6545	6.2955
Total	80	0.8168	0.0769	0.0673	15.4791	2.6933	6.5291
F-value		4.586	263.155	127.771	2.704	17.338	13.989
Sig.		0.005	0.000	0.000	0.051	0.000	0.000

Figure 4 is the scatter plot of unit capital and unit labour of construction firms arranged in accordance to the types of output. Table 3 shows that the residential sub-sector is most productive efficient (0.1674), and the civil engineering sub-sector has lowest productive efficiency level (0.0092). The highest value of labour productivity of civil sector is because of its high capital intensity level (10.2025), but it has low capital productivity (1.8730). Compare with residential factor, which has lowest level of capital intensity (4.4540), but its capital productivity is the highest.

The observations propose that high productive efficiency can only be achieved in optimizing all the production factors and not the labour factor alone.

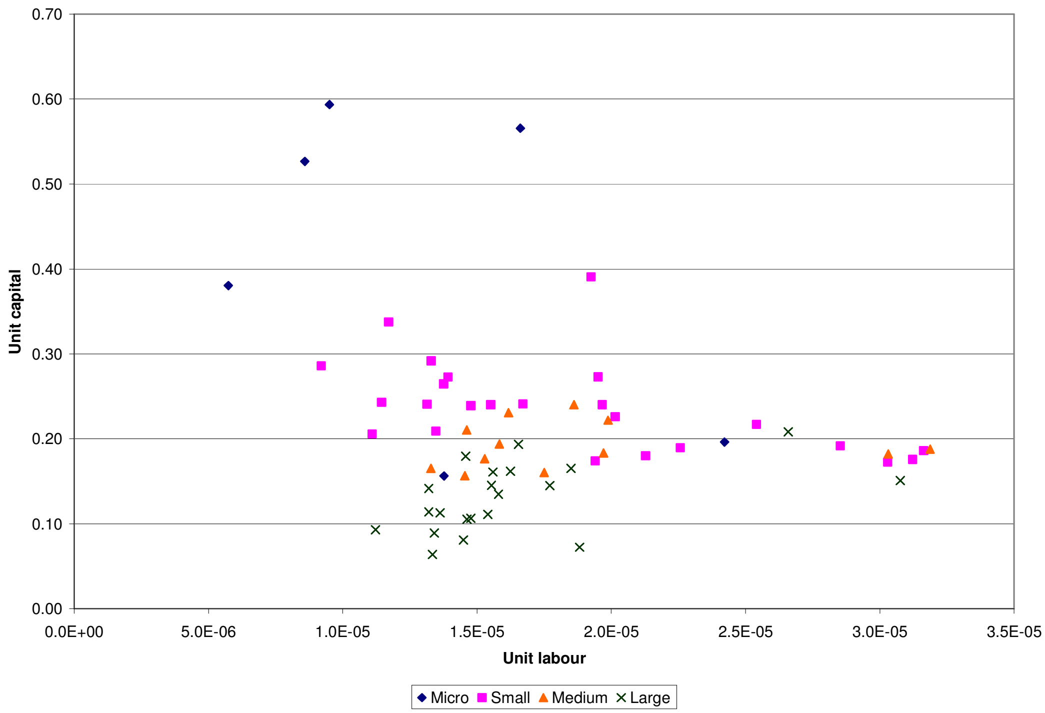

Figure 5 Technical Efficiency According to the Firm size

Table 5: Means and One-way ANOVA Comparing Productive Efficiency and Productivity Indicators on Firm Size

Type of work	N	Technical efficiency	Allocative Efficiency	Productivity Efficiency	Labour productivity	Capital productivity	Capital Intensity
Micro	6	0.5930	0.4796	0.2747	25.8262	0.9531	37.2351
Small	24	0.5108	0.5621	0.2751	19.2227	1.2416	13.7018
Medium	12	0.5290	0.6190	0.3217	19.5962	1.5570	10.0543
Large	21	0.6712	0.8175	0.5605	21.5544	2.2981	7.5327
Total	63	0.5756	0.6502	0.3791	20.7000	1.6264	13.1919
F-value		7.554	9.120	16.402	4.456	12.815	21.913
Sig.		.000	.000	.000	.007	.000	.000

Figure 5 is the scatter plot of unit capital and unit labour of construction firms arranged in accordance to the Firm sizes. Table 3 shows that shows that the PE increases when the firm size increase. This relationship is applied to the capital productivity and allocative efficiency too. The micro-size firm is having the highest labour productivity because of relatively higher capital intensity.

Larger firms are likely to be more technologically advanced and systematically managed, therefore they are more efficient. In addition the larger firms able to pay higher wages per worker. Grunberg and Ive (2000) found an implied bargain that workers will work with above average intensity and in return will receive above average wages in large firm (Gruneberg and Ive 2000).

On the other hand, the high labour productivity of micro-sized firm is achieved by its shorter communication lines, supervision is in the hand of business owner and decisions are made on the spot. Besides, they have inherited free-enterprise spirit and no-nonsense approach to do business. Their natural tendency towards diversity and flexibility enable them to provide high-quality products and services in an efficient manner, and at competitive prices (Oberlender 1996).

Conclusion

Productivity varies due to differences in technology, differences in the efficient of the production process, and the differences in the environment in which production occurs (Lovell 1993). TE, AE and PE are success indicators, performance measures, by which production units are evaluated. Only by measuring efficiency and productivity, and separating their effects from effects of the production environment, can we explore hypotheses concerning the sources of efficiency or productivity differentials (Lovell 1993).

The result also demonstrates that merely invest in capital alone is not sufficient to achieve productive efficiency. Farrell's method of productive efficiency is able to reveal the effect of allocative efficiency, which may be resulted of poor capital productivity. Capital productivity shows up in two ways: the amount of asset used to create a given level of capacity, and the extent to which that capacity is utilized. Different level of capital utilization may results from the manager's actions, especially their management decisions and operational practices.

Finally, it is worth to note Farrel has cautioned that *"this argument is not entirely conclusive, as it is impossible to say what will happen to the technical efficiency of a firm as it changes the proportions of its inputs, but, with this qualification, it seems the best measurement available"* (Farrell 1957).

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