2011 International Conference on Modeling, Simulation and Control
IPCSIT vol.10 (2011) © (2011) IACSIT Press, Singapore

ECONOMIC PRODUCTIVITY QUANTIFICATION AND SIMULATION MODELS FOR THE AIR TRANSPORT INDUSTRY

DEEPAK.H.NATH
Principal Consultant
ENDESCO INTERNATIONAL CONSULTING GROUP
Australia, India, Singapore
Email: deepnat@gmail.com

Abstract. The Paper aims at filling the gaps in the the conceptual and practical problems associated with Quantification of productivity. Perceiving productivity change is a subject about which various attempts have been made conventionally in the past with inadequate or limited success. When productivity is quantified in different units of measurement, such as output per man hour; output per machine hour; output per unit of material consumed and the like, they pose problems of aggregation and disaggregation*. With a view to overcome the aforesaid problems of aggregation and disaggregation, **Economic Productivity Measurement models for Simulation** are developed exemplified to the Airline Industry.The impact of simulation models is to identify the factors' where Productivity could be improved and result in enhanced financial outcome.

Keywords: Productivity Quantification, Productivity Measurement, Economic Productivity, Productivity simulation modeling, Management decision.

Introduction

With globalisation, the World has become more integrated, highly competitive and substantially transformed in terms of manufacture, service and trade opportunities. While most of the existing trade barriers among nations have been significantly relaxed with multilateral trade, the cross border restrictions on movement of capital, labour and technology have also diminished.

Productivity is the bottom-line economic measure of any contribution in all economic systems. With this in mind, CEOs and line managers have increasingly begun to question their huge investments in their respective businesses. While major success stories exist, so do equally impressive failures. The lack of good quantitative measures for Productivity and value created has made the manager's job of justifying expenditures and investments particularly difficult. Academics have had similar problems assessing the contributions of the various resources used in the business.

Econometric estimates have indicated low capital productivity in a variety of manufacturing and service industries. Productivity has always been widely discussed but little understood, more so when it is related with any Economic system. Thus, the increased interest in the "productivity paradox," has engendered a significant amount of research, but this has only deepened the mystery. As aptly stated by the *Nobel Laureate economist Robert Solow*,**:** "we see computers everywhere except in the productivity statistics." *This has been due to deficiencies of methodology in measuring productivity*.

Statement of the Problem

* Detailed discussions may be seen in the book "Enterprise Productivity Measurement and International Labour Productivity Handbook" (ISBN : 0 646 19740 1 – 1995) by M. R. Ramsay, published for the RIPER FOUNDATION by the Advanced Productivity and Quality Centre of Australia, Sydney, Australia (Pages 18 to 49)

The concept of Productivity Measurement in Business, Industry and Service Systems in the 20th Century has largely been carried out using Physical Units of Measurement such as Output per man hour/day/year; Output per unit of Material consumed and the like, exemplified as under:-

Service – Example: Transportation- Airlines

- Number of ton-kilometers moved per day with standard work force strength.
- Number of ton-kilometers moved per 1000 litres of fuel.
- Number of passenger kilometers transported per man-day.
- Number of revenue hours flown per revenue earning flight.

Not frequently however, the output is expressed in monetary value.

In today's world, because of globalisation and higher competition, the measurement of productivity is considered as vital both for organisations and for the State. Productivity is often used to trace technological change although the link between technological change and productivity change is not straightforward. Technology can be viewed as the currently known method of transforming inputs into outputs. It can be embodied in a product (e.g. advances in design) or disembodied (e.g. new organisational techniques).

Problem of measuring inputs may become highly complex when the inputs are of a heterogonous nature, as it often happens. Many modern approaches have some drawbacks and limitations.

The Paper aims at filling the above mentioned gaps in the process of Measuring Productivity by developing **Economic Productivity Measurement models for Simulation** Exemplified to the Airline Industry, which are based on the principles of the Ramsay Productivity Models System (RAPMODS System) [1].

Inadequacies in Productivity Measurement Methodology

There are many inadequacies in the measurement of productivity, among them being:-

1. Cost per person hour of the work force comprising different skills not being considered in work force physical resource productivity measurement.
2. Lack of available methodology to establish a link and study the sensitivities between factors' of productivity and Total/Aggregate productivity when measured in conventional physical units.
3. Inability to perceive the quantitative links among factors' of productivity in physical units of measurement, profitability and Return on Investment.
4. Lack of proper understanding in perceiving the reasons and links between changes in input factor proportions and factors' of productivity (example: In interpreting inter-period changes in the proportion of man power cost to total expenditure; In interpreting inter-period changes in the proportion of materials consumed to total expenditure and the like).
5. Lack of simulation capabilities for scenario construction in Management Decision Making.

Operational definitions of the concept

a. **Factor Productivity Measure (FPM)** which gives the System Output in monetary value per unit monetary value of each factor Input (e.g. Rupees of System Output per Rupee each of the factor Input for providing services covering any time period).

b. **Total Productivity Measure (TPM),** which gives the System Output in monetary value per unit monetary value of Total System Input during a specific period (e.g. System Output in dollars per Dollar of Total System Input (TSI) for providing services covering any time period.

Objectives and Scope

1. To develop Economic Productivity Measurement Simulation models exemplified to Airlines industry and to carryout Simulation studies for Scenario Construction, while dealing with "what if" situations in the process of decision making in Airlines Management.
2. To conduct Economic Productivity Simulation for developing productivity targeted financial budgets, Monitoring and Control, with a preventive approach for achieving Corporate Goals.

Developing Algebraic Models of Economic Productivity with simulation capabilities both Factors' and Aggregate for benchmarking and to develop productivity targeted budgeting, monitoring and control with a view to enhance the quality of management and improve financial results of airlines including competitive capability.

Source of Data

Data is collected from the published Annual reports (2002-2006) of the Singapore Airlines incorporating Profit and Loss accounts, Balance Sheets and available details of operations.

Economic Productivity Simulation Models

The following is based on the models of Factor Productivity Measures (FPMs) and Total/Overall productivity Measures for the Airline Industry have been developed (Factors' of the Singapore Airlines (SA) have been used for exemplification purpose):-

1. Factor Productivity Measure (Staff Costs) – FPM (SC)

$$\text{FPM(SC)} = \left[\frac{\text{RAPMODS System Output (RSO) (\$)}}{\text{Staff Costs (\$)}}\right] = \left[\frac{\$\,13{,}225.4}{\$\,2{,}481.1}\right] = 5.3305$$

FPM (SC) 5.3305 means, for every dollar spent on Employee Costs, an RSO [3] of $5.3305 has been achieved by the Singapore Airlines. If this figure is improved, Economic Productivity of Employee Costs will have improved. On the similar lines Economic Productivity Measurements may be computed to all other input resources (Table 1).

Table 1: Factor Productivity Measures (FPMs)

Factor Productivity Measures (FPMs)						Benchmark FPMs
Year	**2002**	**2003**	**2004**	**2005**	**2006**	
FPM (Fuel costs) – FC	5.2349	4.6183	4.9593	4.8789	5.3305	5.3305
FPM (Staff costs) – SC	9.6079	9.5101	8.2761	9.7615	10.7725	10.7725
FPM (Depreciation) – D	0.0000	0.0000	0.0000	0.0000	1093.0083	1093.0083
FPM (Landing, parking and over flying charges) - LPFC	5174.3889	241.1372	348.8357	275.6472	241.7806	5174.3889
FPM (Handling charges) – HC	5.2803	5.5609	5.3931	4.3810	3.1190	5.5609
FPM (Other operating expenses) – OOE	16.6082	13.2781	15.9938	19.7319	41.4200	41.4200
FPM (Commission and incentives) - CI	15.9212	15.3500	16.5465	26.4998	29.9488	29.9488
FPM (Rentals on leased aircraft) – RLA	17.5205	17.9984	18.9327	18.7325	20.2564	20.2564
FPM (Material costs) - MC	16.9900	19.8981	19.8283	20.6868	22.2913	22.2913
FPM (Aircraft maintenance and overhaul costs) - AMOC	29.6527	28.9230	27.6462	35.2170	39.1284	39.1284
FPM (In-flight meals) - IFM	29.6527	33.1593	39.4324	40.2515	41.9588	41.9588
FPM (Advertising and sales costs) - ASC	42.7635	47.5638	49.3054	48.0558	53.4360	53.4360
FPM (Company accommodation and utilities) - CAU	48.7129	49.7071	51.1382	45.7630	54.3361	54.3361
FPM (Other passenger costs) - OPC	93.3257	57.9268	73.1640	90.6818	115.4049	115.4049
FPM (Crew expenses) - CE	66.1969	76.5798	0.0000	0.0000	83.6521	83.6521
FPM (Insurance expenses) - IE	77.5512	79.3336	92.4943	0.0000	107.9624	107.9624
FPM (Finance charges) - FIC	92.7679	104.8423	108.4062	109.0360	112.9411	112.9411
FPM (Amortisation of intangible assets) - AIA	42.3167	28.8666	23.6442	26.2755	29.4946	42.3167
FPM (Provision for impairment of fixed assets) - PIFA	211.6795	189.5594	150.0369	152.2284	137.3354	211.6795

2. Total Productivity Measure (TPM)

$$\text{TPM} = \left[\frac{\text{Output}}{\text{Input}}\right]$$

$$= \left[\frac{\text{Output}}{\frac{\text{Output}}{\text{FPM}_{(\text{IFM})}} + \frac{\text{Output}}{\text{FPM}_{(\text{ASC})}} + \frac{\text{Output}}{\text{FPM}_{(\text{FC})}} + \frac{\text{Output}}{\text{FPM}_{(\text{SC})}} + \frac{\text{Output}}{\text{FPM}_{(\text{D})}} + \frac{\text{Output}}{\text{FPM}_{(\text{HC})}} + \frac{\text{Output}}{\text{FPM}_{(\text{RLA})}} + \frac{\text{Output}}{\text{FPM}_{(\text{LPFC})}} + \frac{\text{Output}}{\text{FPM}_{(\text{MC})}} + \frac{\text{Output}}{\text{FPM}_{(\text{AMOV})}} + \frac{\text{Output}}{\text{FPM}_{(\text{CI})}} + \frac{\text{Output}}{\text{FPM}_{(\text{IE})}} + \frac{\text{Output}}{\text{FPM}_{(\text{OPC})}} + \frac{\text{Output}}{\text{FPM}_{(\text{CE})}} + \frac{\text{Output}}{\text{FPM}_{(\text{OOE})}} + \frac{\text{Output}}{\text{FPM}_{(\text{CAU})}} + \frac{\text{Output}}{\text{FPM}_{(\text{FIC})}} + \frac{\text{Output}}{\text{FPM}_{(\text{AIA})}} + \frac{\text{Output}}{\text{FPM}_{(\text{PIFA})}}} \right]$$

Dividing the numerator and denominator by Output, we have

$$= \left[\frac{1}{\frac{1}{\text{FPM}_{(\text{IFM})}} + \frac{1}{\text{FPM}_{(\text{ASC})}} + \frac{1}{\text{FPM}_{(\text{FC})}} + \frac{1}{\text{FPM}_{(\text{SC})}} + \frac{1}{\text{FPM}_{(\text{D})}} + \frac{1}{\text{FPM}_{(\text{HC})}} + \frac{1}{\text{FPM}_{(\text{RLA})}} + \frac{1}{\text{FPM}_{(\text{LPFC})}} + \frac{1}{\text{FPM}_{(\text{MC})}} + \frac{1}{\text{FPM}_{(\text{AMOV})}} + \frac{1}{\text{FPM}_{(\text{CI})}} + \frac{1}{\text{FPM}_{(\text{IE})}} + \frac{1}{\text{FPM}_{(\text{OPC})}} + \frac{1}{\text{FPM}_{(\text{CE})}} + \frac{1}{\text{FPM}_{(\text{OOE})}} + \frac{1}{\text{FPM}_{(\text{CAU})}} + \frac{1}{\text{FPM}_{(\text{FIC})}} + \frac{1}{\text{FPM}_{(\text{AIA})}} + \frac{1}{\text{FPM}_{(\text{PIFA})}}} \right]$$

3. Per unit profit (K)

$$= 1 - \left(\frac{1}{\text{FPM}_{(\text{IFM})}} + \frac{1}{\text{FPM}_{(\text{ASC})}} + \frac{1}{\text{FPM}_{(\text{FC})}} + \frac{1}{\text{FPM}_{(\text{SC})}} + \frac{1}{\text{FPM}_{(\text{D})}} + \frac{1}{\text{FPM}_{(\text{HC})}} + \frac{1}{\text{FPM}_{(\text{RLA})}} + \frac{1}{\text{FPM}_{(\text{LPFC})}} + \frac{1}{\text{FPM}_{(\text{MC})}} + \frac{1}{\text{FPM}_{(\text{AMOV})}} + \frac{1}{\text{FPM}_{(\text{CI})}} + \frac{1}{\text{FPM}_{(\text{IE})}} + \frac{1}{\text{FPM}_{(\text{OPC})}} + \frac{1}{\text{FPM}_{(\text{CE})}} + \frac{1}{\text{FPM}_{(\text{OOE})}} + \frac{1}{\text{FPM}_{(\text{CAU})}} + \frac{1}{\text{FPM}_{(\text{FIC})}} + \frac{1}{\text{FPM}_{(\text{AIA})}} + \frac{1}{\text{FPM}_{(\text{PIFA})}} \right)$$

Substituting the respective measures of FPMs from Table 1 in the aforesaid models we compute Total Productivity Measure (TPM) and Per Unit Profit (K) for the five year period 2002 to 2006 (Show in Table 2)

Table 2

Year	2002	2003	2004	2005	2006
TPM	1.0955	1.0524	1.0679	1.0946	1.0819
K	0.0871	0.0498	0.0636	0.0865	0.0757

4. Simulated Total Productivity Measure (TPM_S) and Per unit Profit (K_s)

Substituting the benchmark measures of FPMs (Table 1) in the aforesaid models of Total Productivity Measure (TPM) and Per Unit Profit (K) we have

$TPM_s = 1.3042$ and $K_s = 0.2333$

5. Computation of Estimated Loss of Profits

Considering the established potential improvements in respect of Total and individual Factors' of Productivity Measure relative to the best productivity achieved during the period (2002 to 2006) or any Benchmarked levels of Productivity of the studied Airlines and thus compute simulated :-

Exemplification: Economic Productivity Surplus (EPS) - Singapore Airlines (2006)

$$EPS_{(2006)} = K \times RSO_{(2006)} = 0.0757 \times \$13225.4\,M = \$1001.16M$$

$$EPS_{(Simuleted)} = K_{(Simuleted)} \times RSO_{(2006)}$$

$$EPS_{(S)} = 0.2333 \times \$13225.4\,M = \$3{,}085.36M$$

Hence, **the estimated loss of profit due to not achieving the benchmarked Factor Productivity Measures (FPMs) for the year 2006 is**

= \$3,085.36M – \$1001.16M = **\$2084.20M**

References

[1] Ramsay, M. R., "Enterprise Productivity Measurement and International Labour Productivity Handbook – 1995,"

[2] Aigner W, Productivity Everywhere – Wealth and Prosperity for All - 1997.

[3] Deepak H Nath., "Productivity Perspective for The Air Transport Industry" 16th World Productivity Congress and European Productivity Conference Nov 2010– Published in the Conference Proceedings ISBN 978 975 440 388 6 (2.c)

[4] IATA, World Industry Statistics,www.iata.org

[5] David N. Card, "The Challenge of Productivity Measurement" (Paper – 2006).

[6] S Borenstein, Airline Competition, Journal of Economic perspective (Paper 1992)

[7] Ramsay, M. R – RAPMODS Productivity Budgeting System (Book) January 1980 – ISBN 09595082 01