
Efficiency and Capacity Utilisation of Tourism Industries using DEA

A Seminar in the Tourism Series, VMS, Victoria University of Wellington, NZ

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Seminar Overview



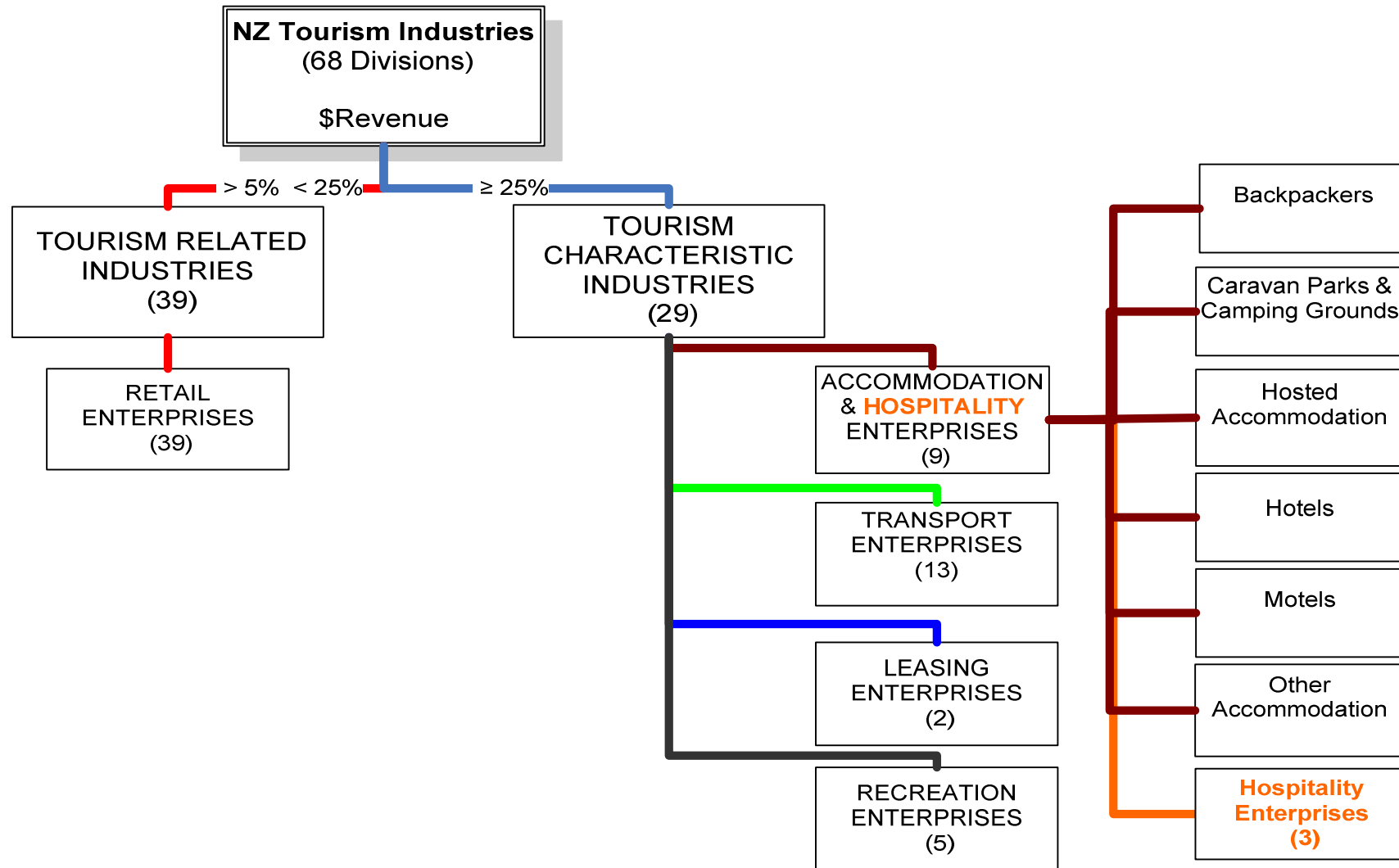
- Where it all started!
- Tourism Economic Structure
- Tourism Financial Benchmarks
- Financial and Economic Sustainability
- Some Intermediate Results and Conclusions
- Triangulation using DEA
- DEA Discussion and Results

2001 Research Question

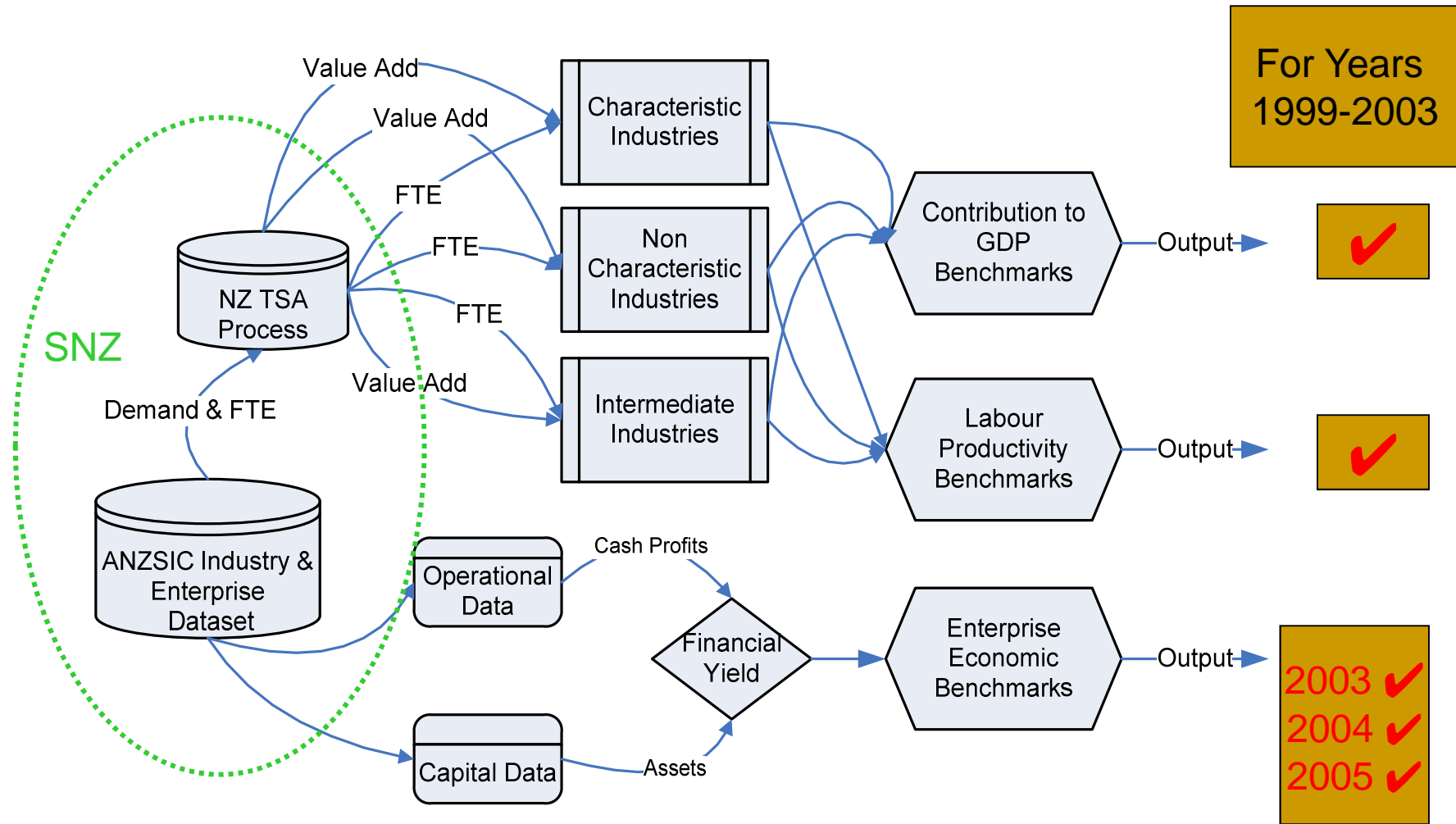


- Are there “yield” strategies to improve the financial and economic viability of tourism enterprises? – NZ Tourism Strategy 2010 #29.
- Research programme to address “tourism yield” undertaken by TIANZ and TMT and managed by Lincoln University from 2004-2007.
- My role in this programme addressed tourism related and tourism characteristic enterprise performance via a benchmark system.

NZ Tourism Economic Structure



A NZ Tourism Benchmark System



Approaches to Financial & Economic Sustainability



- Financial sustainability criteria are also legal requirements under the Companies Act – solvency.
- Economic Sustainability combines **Pareto efficiency** and **long term equity**. (welfare monotonicity).
- Enterprise Economic Sustainability was modelled via estimations of **enterprise economic returns (EER)** versus estimations of investor's expected economic returns (IER), over time – an opportunity approach using free cash flows.
- **EES \approx Average (EER \geq IER) over time.**

Measures of Economic Sustainability

– Financial Yield



- Adoption of Financial Yield (FY) as a proxy for enterprise economic returns (EER).

$$\text{EER} \approx \text{FY} = \frac{(\text{GOS} - \text{Tax} + \text{Financing})}{\text{AssetsEmployed}} \approx \frac{\text{FreeCashFlow}}{\text{AssetsEmployed}}$$

- Where GOS is **gross operating surplus** and Financing includes all costs of money or asset leases.
- FY is “free cash return on assets (resources) employed”
 - After Miller & Modigliani (1961), Stewart (1991).

Measures of Economic Sustainability



– Financial Yield continued

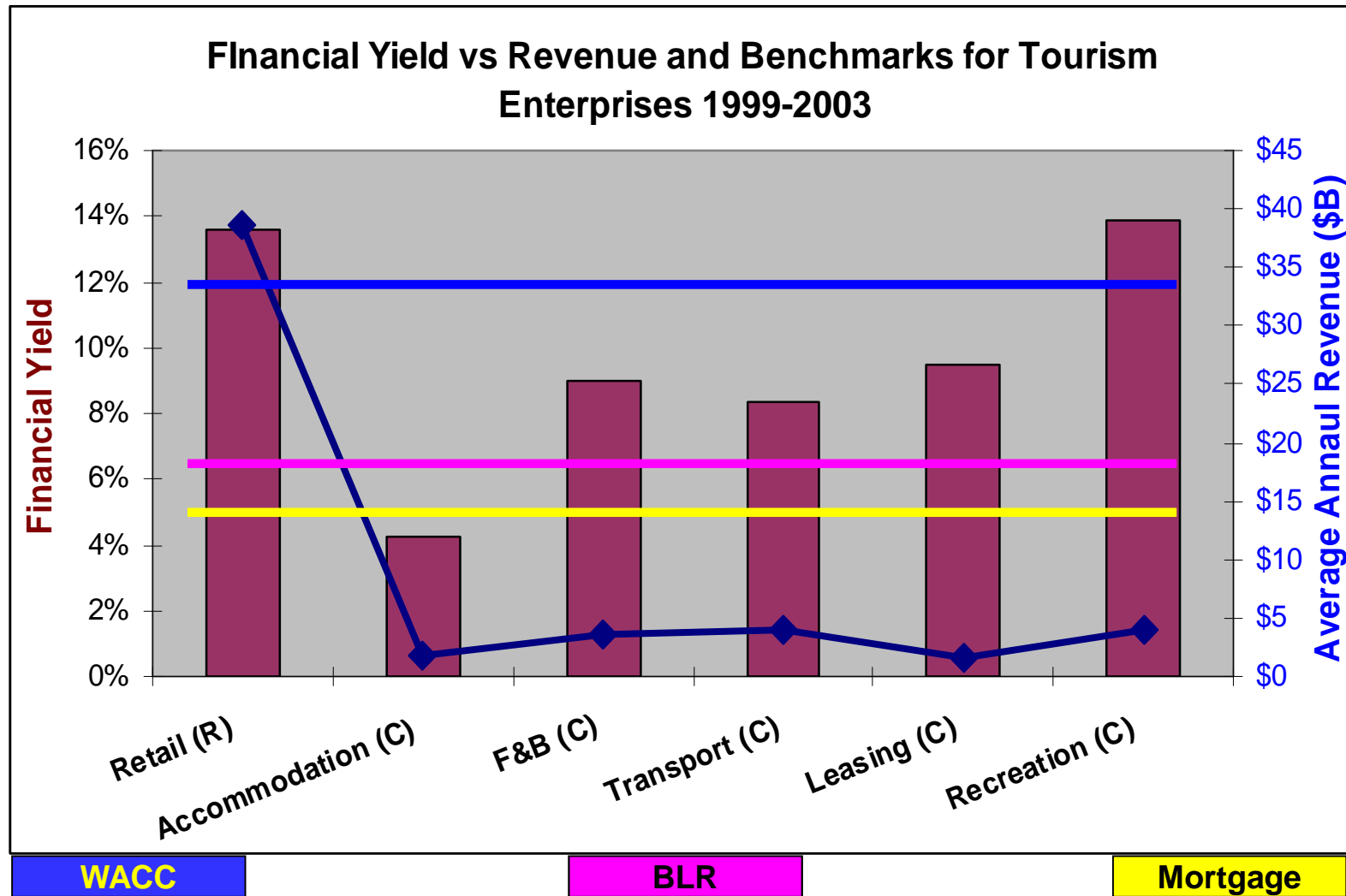
For Investors

$$\text{IER} = \frac{(\text{Returns} - \text{Tax})}{\text{Investment}} \sim \frac{\text{InvestorFCF}}{\text{Investment}}$$

- IER is a %, (e.g. **Mortgage Rate**, **Lending Rate** or **Risk Adjusted Rate** might reflect an appropriate target to aim for).
- **Owner-Operators** might use a Mortgage Rate (5%),
- **Trading Banks** use the Base Lending Rate (6.3%), and **Equity Investors** use the Weighted Average Cost of Capital (12%).
- These rates are indicative the Pareto efficiency hurdles that tourism businesses should exceed to demonstrate economic sustainability.

- Sources:
 - In-depth survey of a sample of tourism enterprises in Rotorua and Christchurch, n=70.
 - Extraction and analysis of tourism related and characteristic enterprises from Statistics NZ Datalab. Financial Data based on Annual Enterprise Surveys 1999-2003, n~57,000.
- Data Issues:
 - Privacy, confidentiality and minor willingness to co-operate (in RO and CHCH)

Tourism's FY Profile & Benchmarks



Observations

- Retail and Recreation are FY exemplars.
- Accommodation is consistently below each Investor benchmark.
- Economic sustainability is an *issue* for Accommodation in the absence of property-based capital gains (would have added another 2% for 1999-2003).
- High asset structures appear to underpin Accommodation sector weakness.

Diagnosis?

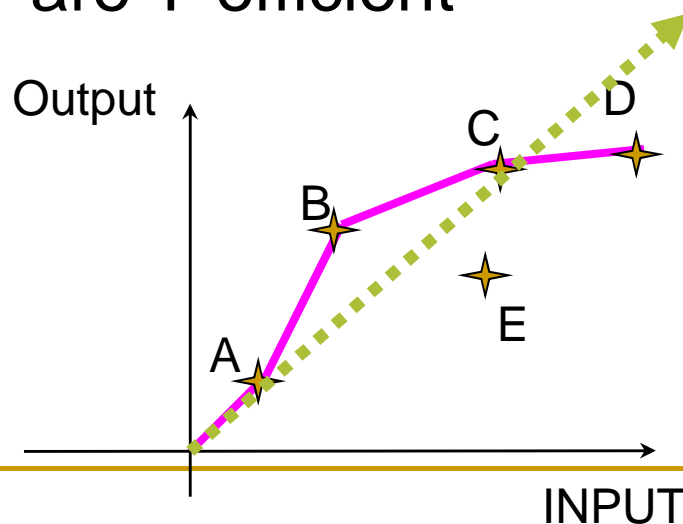
- FY is a useful as a performance hurdle.
- Its decision support capabilities are limited as there are many contributing variables.
- Triangulation needed!
 - Postulate that analysis of enterprise efficiency and resource utilisation may help to refine proprietor decision strategies.

Efficiency

- Standard approach: Output/Input.
- Choice of inputs and outputs important.
- Comparisons of one enterprise with another can be problematic if the relationship between inputs and outputs is unknown – i.e. unknown production functions.
- Data Envelopment Analysis is a method of gauging relative efficiency where production functions are unknown.

Data Envelopment Analysis

- Data envelopment analysis is a
 - Frontier methodology (vs. regression)
 - A non-parametric form of analysis
 - Provides “relative” technical (T) efficiency rankings.
 - E.g. A, B, C & D are on the Efficiency Frontier and are T-efficient



E is not on the frontier
and is inefficient with
respect to A, B, C & D

DEA Formulation

- DEA is an exhaustive mathematical search comparing **each enterprise's** data with **every other enterprise's data** to determine if notionally greater outputs could have been produced by its inputs. Inputs are unrestricted.
- Linear Programming implements this search
- Results identify relative technical efficiency, returns to scale, exemplars & optimum parameters for anomalars.

Those Mathematical bits!

Basic DEA Problem

Output Orientation
(envelopment model)

$$\varphi^* = \max \varphi$$

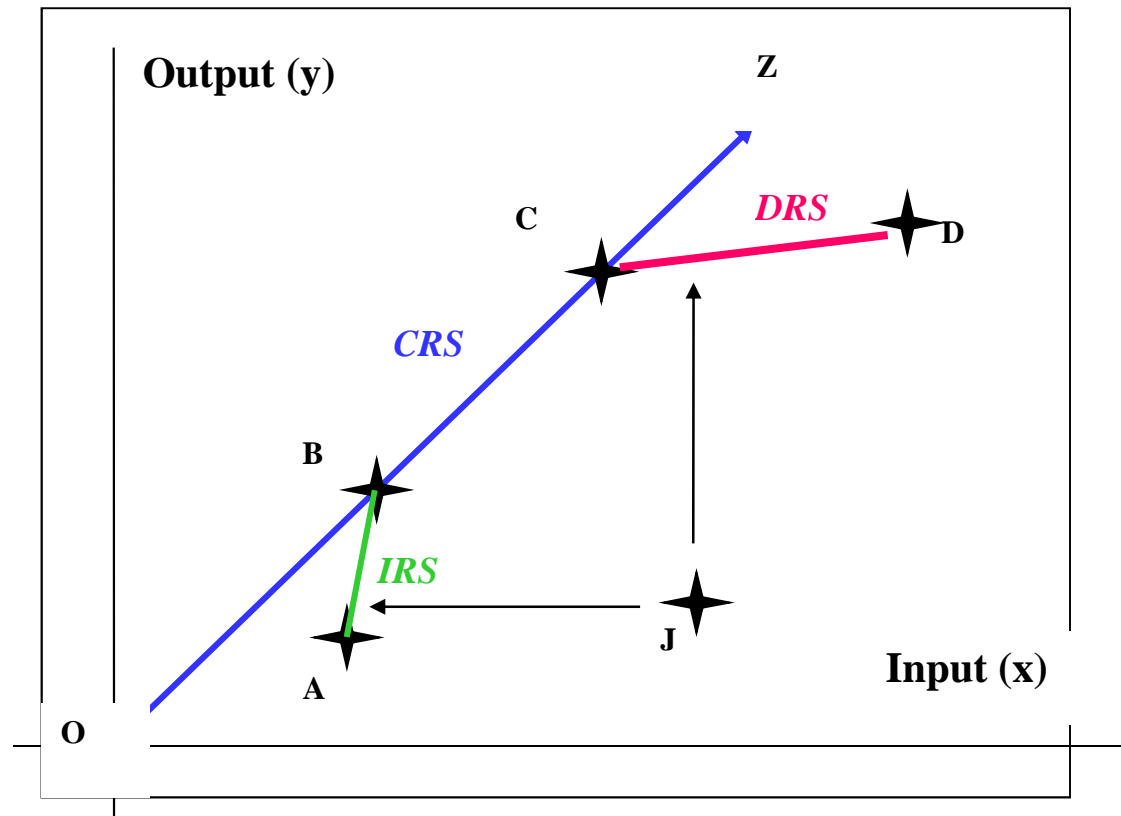
Subject to

$$\sum_i x_{ij} \lambda_j \leq x_{io}, \forall i \in m$$

$$\sum_i y_{rj} \lambda_j \geq \varphi \cdot y_{ro}, \forall r \in s$$

$$\lambda_j \geq 0$$

Returns (productivity) to Scale



Tourism Data – Ex SNZ Datalab



Related and Characteristic Division	DMU	Rev	Matls	Int	Labour	Deprn(f)	Assets(f)	OSBT(o)	SWWP(o)
G511010 Supermarkets	1	7.7507	6.7584	0.0186	0.5958	0.1105	1.5037	0.2673	0.0268
G511020 Groceries and Dairies	2	1.2946	1.1577	0.0067	0.0413	0.0140	0.4283	0.0749	0.0314
G512100 Fresh Meat/ Fish and Poultry Retailing	3	0.4514	0.3681	0.0036	0.0547	0.0071	0.0912	0.0180	0.0065
G512200 Fruit and Vegetable Retailing	4	0.2731	0.2370	0.0020	0.0185	0.0039	0.0615	0.0117	0.0034
G512300 Liquor Retailing	5	0.8821	0.7899	0.0042	0.0466	0.0105	0.2436	0.0309	0.0070
H571010 Hotels (Accommodation)	40	0.9085	0.5203	0.0506	0.2643	0.0666	1.4343	0.0068	0.0074
H571020 Motels and Motor Inns	41	0.4569	0.2792	0.0244	0.0710	0.0389	1.0012	0.0434	0.0127
H571030 Hosted Accommodation	42	0.0809	0.0477	0.0067	0.0123	0.0101	0.3462	0.0042	0.0034
H571040 Backpacker and Youth Hostels	43	0.0588	0.0315	0.0042	0.0096	0.0060	0.1374	0.0075	0.0013
H571050 Caravan Parks and Camping Grounds	44	0.0819	0.0484	0.0038	0.0129	0.0063	0.2955	0.0105	0.0012
H571090 Accommodation nec	45	0.1464	0.0789	0.0048	0.0409	0.0098	0.3517	0.0119	0.0005
P921000 Libraries	62	0.0588	0.0260	0.0001	0.0225	0.0071	0.1088	0.0032	0.0002
P923x00 Zoos, Botanic Gardens Recreation Parks & Gardens	63	0.2248	0.1072	0.0013	0.0973	0.0125	0.4409	0.0065	0.0007
P924x00 & P925x00 Creative Arts	64	0.3419	0.1798	0.0044	0.0609	0.0160	0.3492	0.0808	0.0150
P93xxxx0 Racing, Gambling, Lotteries and Other Recreation	65	3.3158	2.1076	0.2485	0.4627	0.1822	2.8932	0.3148	0.0223

Data is the Annual Average for 1999-2003, in \$B

DEA Findings



Consolidated Division	Average T-Efficiency NIRS - Output
Retail (R)	81%
Accommodation (C)	48%
F&B (C)	52%
Transport (C)	67%
Leasing (C)	88%
Recreation (C)	84%

EXEMPLARS – 100% NIRS Efficient

- G511020 Groceries and Dairies
- G522100 Clothing Retailing
- G523200 Floor Covering Retailing
- G523500 Recorded Music Retailing
- G524200 Toy and Game Retailing
- G524400 Photographic Equipment Retailing
- G525100 Pharmaceutical/ Cosmetic and Toiletry Retailing
- G525200 Antique and Used Good Retailing
- G531300 Trailer and Caravan Dealing
- G532200 Automotive Electrical Services
- G532300 Smash Repairing
- G532400 Tyre Retailing
- G532900 Automotive Repair and Services nec
- I630300 Inland Water Transport
- I662x00 Stevedoring, Terminals, Ports and Services nec
- I663000 Services to Air Transport
- I664100 Travel Agency Services
- L774x00 Other Transport Equipment & Plant Leasing
- P921000 Libraries
- P924x00 & P925x00 Creative Arts
- P93xxxx0 Racing, Gambling, Lotteries and Other Recreation

FY Concordance Tests R^2

Model	Out-CRS	Out-VRS	Out-NIRS
Spearman	0.389	0.430	0.447
Pearson	0.400	0.410	0.423

Accommodation Scale Efficiency

Division Results 1999-2003



Selected Divisions	Scale	Scale Efficiency	FY
H571010 Hotels (Accommodation)	Decr	85%	3.8%
H571020 Motels and Motor Inns	Decr	90%	5.3%
H571030 Hosted Accommodation	Incr	99%	2.7%
H571040 Backpacker and Youth Hostels	Incr	90%	6.7%
H571050 Caravan Parks and Camping Grounds	Incr	96%	3.7%
H571090 Accommodation nec	Incr	95%	3.6%
H572000 Pubs/ Taverns and Bars	Decr	92%	11.7%
H573000 Cafes and Restaurants	Decr	53%	10.0%

Improving FY – But How?

- The Output DEA model **broadly** mirrors FY performance, but generally improvements to FY are related to trading rather than to Asset substitution (particularly in Tourism Characteristic Industries).
- If Assets were constrained, what would the optimum trading parameters need to be to maximise FY?

DEA Capacity Utilisation Model



- Capacity Utilisation is the degree to which input restrictions limit outputs.
- Construct a DEA model where inputs are divided into two separate parts, an unconstrained Variable portion and a constrained Fixed portion.
- An optimal operating regime can be calculated by **freezing Assets and Depreciation** and allowing Revenue, Materials, Labour & Financial Expenses to vary.

Capacity Utilisation (CU) Results



Spearman FY:CU R ²
0.82
Pearson FY:CU R ²
0.74

Consolidated Division	Average Capacity Utilisation**
Retail	50%
Accommodation	6%
F&B	11%
Transport	23%
Leasing	12%
Recreation	24%

Average Capacity Improvement Factors

Consolidated Division	Rev Opt	Matls Opt	Int Opt	Labour Opt	FY Opt
Retail (R)	1.23	1.28	1.48	1.01	24%
Accommodation (C)	7.19	9.88	1.44	3.42	22%
F&B (C)	4.00	5.41	1.88	1.43	27%
Transport (C)	5.72	11.39	1.94	2.37	26%
Leasing (C)	14.70	27.28	1.41	13.94	37%
Recreation (C)	5.42	8.85	19.41	1.91	27%

Conclusions

- Interesting application of DEA to examine relationships between FY, Efficiency & Capacity Utilisation
 - FY concords well with Capacity Utilisation but less well with Technical Efficiency. This is consistent with the role of capital resources in Tourism production.
- Asset utilisation is one of NZ tourism's greatest challenges (seasonality, pricing, scale of operation).
- Triangulation is an essential component of enterprise benchmarking given the number of variables involved.

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