Scale Advantage - Using Data Envelopment Analysis to Detect Economies of Scale in the Insurance Industry

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Abstract

Insurer A is the largest insurer in its product category within New Zealand (Investment Savings and Insurance Association, June 2010), this led to the assumption that Insurer A has scale advantage. This assumption has an impact on Insurer A's business decisions so this assumption was examined further. An optimisation technique called Data Envelopment Analysis (DEA) was used to determine efficiency in the insurance market and therefore scale advantage.

It was found that Insurer A did not have scale advantage in the adviser market but did have scale advantage in the institutional market. It was also found that Insurer A is spending efficiency on commission. Potential reasons for these results were explored and their impact on business decisions was discussed.

Key words: Data Envelopment Analysis, Efficiency, Insurance, Scale, Scale Advantage, Economies of Scale.

1 The Problem

For the purposes of thir report I will refer to research I did within my own organisation, which is refered to as Insurer A due to commercial sensitivity reasons. Insurer A is the largest insurer in its product category within New Zealand (Investment Savings and Insurance Association, June 2010). As a result of its size the employees of Insurer A assumed this size advantage led to economies of scale, in effect scale advantage (Staff of Insurer A, 2010). This scale advantage would mean that Insurer A is the most efficient insurer and therefore could extract a higher return on capital then any other insurer. This scale advantage premise leads to numerous conclusions including that the company should seek to grow in order to increase efficiency further. Therefore understanding whether Insurer A does in fact have scale advantage is very important.

This leads to the following question, 'does Insurer A have scale advantage?'. This question effectively translates to; 'Is Insurer A more efficient then its competitors because of its size?'. In effect we are trying to prove the hypothesis that because Insurer A is larger then its competitors, Insurer A is more efficient.

Efficiency as defined in our question is a relative measure. To determine if Insurer A is efficient we need to determine how efficient A's competitors are. The method we chose to use to examine this problem was Data Envelopment Analysis (DEA), which is an operations research technique that explores efficiency.

1.1 What is Efficiency?

Efficiency is commonly defined as inputs / outputs (A. Emrouznejad, 1995 –2001). Where we seek to maximise our outputs from a given set of inputs. In the case of the insurance industry we would like to maximise our profit, or similarly we would like to minimise our costs.

2 Introduction to Data Envelopment Analysis (DEA)

DEA is an optimisation technique used to determine the efficient frontier of a group of decision making units, in this case insurance companies. DEA determines the efficiency of each insurer. This efficiency is relative to the performance of the insurers it is being compared to. If an insurer is considered efficient then it is at the highest level of efficiency of those being studied. More than one insurer can be considered efficient.

DEA requires that a set of inputs and outputs be defined, these inputs and outputs are then used to determine efficiency. The premise is that inputs are used to create outputs, and thus define efficiency. The insurer producing the most outputs with the least inputs is deemed to be efficient. (T. Coelli, P. Rao & G. Battese, 2005)

A simple implementation of DEA would involve solving the below mathematical formulation. This programme seeks to maximise each insurer's efficiency by altering the weight assigned to the inputs and outputs as shown below.

$$\textbf{Efficiency of Insurer}_i = maximise \frac{\sum_{j=1}^{m} Outputs_{ji} Weight_i}{\sum_{k=1}^{n} Inputs_{ki} Weight_i}$$

If a particular insurer outputs a superior amount of output X, X will be weighted highly for this insurer, this means each insurer will achieve the highest efficiency possible based on that insurers strengths. An equivalent way to view the problem (the dual or envelopment form of the problem) is to see whether a more efficient insurer can be created by combining the outputs and inputs of other insurers. If this can be done then the insurer is not efficient.

The major advantage of DEA is that it quantifies the efficiency of insurers and produce targets for inefficient companies.

3 Insurance

For the purposes of this paper an insurance company is a company who 'manufactures' insurance policies. Insurance protects against risk, in exchange for a regular premium an insurer agrees to pay its customer an agreed amount under certain circumstances or risks. Insurance works because insured risks are based on historical information and are statistically small. The insurer is therefore able to calculate the expected claims and price insurance accordingly.

3.1 New Business

It is often said that 'insurance is sold and not bought'. Insurance is not tangible and is considered to be a luxury good. As a result of insurance is not prioritised by consumers and sales takes a very important and expensive role in insurance.

At the point of sale there is a mismatch between cashflows arising from an insurance policy. For an insurer a policy will have high upfront sale costs, but it will result in ongoing cashflows over the policy's lifetime. In cashflow accounting an instantaneous

loss would be made when a new policy is sold because the value of its future cashflow is not considered. For this reason Actuaries are able to defer these upfront expenses and spread them over the expected life of a policy, avoiding an instantaneous loss and allowing profit to be recognised in the first year the policy is taken out. The profitability of an insurance policy is dependent on actual experience, in particular the variance from claims and policy longevity assumptions.

3.2 Distribution Channels

The cost of New Business varies according to how insurance is sold, there are three main distribution channels.

3.2.1 Adviser

This is where an adviser will meet with clients to discuss their needs and then sell them insurance. An adviser may be independent which means that they are not tied to any insurance manufacturer and are typically reimbursed for their efforts on a commission basis. An adviser may also be tied to an insurance company, this means the adviser will be paid a salary (although is also likely to be paid some commission as well) and the insurer will have to cover their costs of doing business.

In recent years the entrance of insurance aggregators, who bargain for commission on behalf of a group of advisers, has seen commission rise from ~100% of first year premium income to ~200% of first year premium (Staff of Insurer A, 2010). Despite the adviser channel being high cost, 70% of New Business is sold through this channel making it valuabe for insurers to maintain **(**Investment Savings and Insurance Association, June 2010).

3.2.2 Institutional

This is where the insurance product is distributed by a corporate partner. One example of this is through a bank – this is significantly cheaper than distributing through Advisers. 30% of New Business is generated through the Institutional channel **(**Investment Savings and Insurance Association, June 2010**)**.

3.2.3 Direct

This is where insurance is sold by the manufacturer online or via a call center, creating the lowest distribution costs. As a result of this a lesser level of advise is offered through the direct channel.

This is an emerging market with 0.05% of business distributed via this method **(**Investment Savings and Insurance Association, June 2010**)**.

3.2.4 Existing Business

Existing Business (as opposed to New Business) is business that the insurer already has on its books and is therefore relatively cheap to maintain. The longer a given policy remains with an insurer the more profitable it is.

4 Previous Efficiency Research Within Insurer A

Efficieny had been explored twice by consultants engaged by Insurer A since 2004. Both of these approaches will be examined below.

4.1 Consultant 1

Consultant 1 created a cost model for the industry based on Insurer A's cost structure. Existing Business and New Business were chosen as cost drivers, this means the model effectively assumes scale advantage. This model was applied to Insurer A's competitors and found that Insurer A had scale advantage. Consultant used this assumption of scale advantage to prove scale advantage – creating a logical fallacy. When the modelled costs were compared to the actual costs it was found that the actual costs were in fact 22% lower than the modelled costs and with a standard deviation of 48% and check. These substantial differences were written off by the consultant as reporting differences. (Consultant 1, 2004)

4.2 Consultant 2

Consultant 2 also touched on scale advantage in a larger piece of work. They did this by comparing the cost of acquiring New Business with the amount of New Business actually acquired. As well as this they compared the cost of maintaining Existing Business with the amount of Existing Business held. They then used these results to draw scale curves, which showed an interaction between scale and efficiency.

Unlike Consultant 2, Consultant 1 had avoided this approach as it is reliant on insurers reporting the breakdown between New Business and Existing Business costs accurately and in a consistent manner with other insurers. Separating these costs is more of an art then a science as it requires separating all fixed and direct costs. The way an insurer does this will depend on the system they use to split costs.

Other failings of this technique include that it is not able to quantify efficiency. There also appeared to be no underlying scientific reason for drawing the scale curves the way they did.

Consultant 2's message was that Insurer A did in fact have scale advantage however their findings did not seem to support this. (Consultant 2, 2004)

4.3 Proposed Technique

Both techniques have their failings, Consultant 1's example fails because it avoids using actual competitor data and Consultant 2's example fails because it relies too strongly on the accuracy of competitor data. Data Envelopment Analysis (DEA) will be used in this study to determine scale advantage.

5 Data envelopment analysis applied

5.1 Previous DEA Research

A large amount of research on the insurance industry has already been published. Typically this research seeks to compare the efficiency of insurers in one country against another or seeks to compare the efficiency of different insurance industries (M. Eling & M. Luhnen, July 2008). None of the research I identified is focussed on trying to determine scale advantage. This does not mean however this research is not useful as they are trying to determine the efficiency of each insurer; they just use this efficiency information in a different way.

The selection of both inputs and outputs are critical to determining efficiency, it is necessary to track the processes that add value to insurers. The majority of frontier efficiency research uses a value added approach to select outputs (M. Eling & M. Luhnen, July 2008). Value is added in insurance via three functions; risk-pooling,

financial services related to insured losses and intermediation (F. Fiordelisi & O. Ricci, March 2010). Input and output choice reflects how value is added.

5.2 Input & Output Choice

This value-added technique requires a number of inputs and outputs, which presented a couple of problems for this research:

- Not all of this information was available for insurers in New Zealand via our limited data sources.
- Having many inputs and outputs creates too many degrees of freedom for a small market such as NZ. When an approximate value added method was trialled for New Zealand insurers it was found that it did not produce meaningful results.

As a result I approached the problem from a different angle; being primarily interested in the advantages that scale offers. It is likely that most of the benefits from scale are derived from policy administration. We are interested in how administration expenses are transformed to premiums. The more efficient an insurer is the more premium they can write for less cost. As discussed previously the premium can be New Business or Existing Business, which will affect how much it costs.

By making a number of assumptions this approach remains consistent with the value-added approach.

- Insurers are being run in a solvent manner. This is a fair assumption due to consistent regulation and professional actuarial standards and is evidenced by the fact that no NZ based insurer has failed recently. Therefore it can be assumed that a consistent proportion of premiums will be used to pay claims. There is also unlikely to be a scale advantage in this instance as underwriting standards will be defined by reinsurance companies who will work with all NZ based insurers.
- Investment returns should be the same across all insurers, as all insurers should pursue low risk investment strategies for risk management purposes. There should be no scale advantage here as all insurance companies should possess sufficient scale to make institutional investments.

By making these assumptions we are able to take a very simple approach to this model:

Input: Operating Expenses

Outputs: Change in Existing Business premiums (as a proxy for New Business)
Existing Business Premium

Both the input and outputs are derived from each insurer's Annual Financial Report and should be largely consistent between insurers.

5.3 Choice of DEA Methodology

There are many different variations of DEA, but the two most basic models are the CCR model developed by Charnes, Cooper and Rhodes in 1978 and the technique developed by Banker, Charnes and Cooper in 1984 (BCC) (T. Coelli, P. Rao & G. Battese, 2005). The key difference between these different formulations is how they handle returns to scale, the CCR is the more simplistic model and assumes return to scale are constant while BCC assumes variable returns to scale.

The focus of this research is scale, so the choice of model is crucial. Allowing variable returns to scale effectively means when defining efficiency of a given insurer it is only compared to other insurers of a similar size. Assuming scale advantage exists this is equivalent to compensating smaller organisations for their reduced efficiency.

Assuming that economies of scale exists within a BCC model a small organisation will appear efficient but within a CCR model the small organisation will appear inefficient.

Indices
o = insurer: 1,…,l
i = insurer: 1,…,l
j = outputs: 1,…,m
k = inputs: 1,…,n
Parameters
θ_o = efficiency of insurer o
x_{ik} = input k for insurer i
q_{ij} = output j for insurer i
Decision Variables
λ_{io} = weight of insurer i while finding the efficiency of insurer o
Model: CCR, Input Oriented, Envelopment Form
minimise θ_o

(1) $$-q_{oj} + \sum_{i=1}^{l} q_{ij}\lambda_{io} \geq 0 \qquad \text{for o} = 1,\ldots,l$$

(2) $$\theta_o x_{ok} - \sum_{i=1}^{l} x_{ik}\lambda_{io} \geq 0 \qquad \text{for j} = 1,\ldots,m$$

$$\lambda_{io} \geq 0 \qquad \text{for k} = 1,\ldots,n$$

Explanation

The objective is to solve the dual of the efficiency maximisation problem, by finding the most efficient combination of insurers, for each insurer by selecting the weighting of the other insurers appropriately.

I chose the input oriented, envelopment form of the CCR technique, as shown above, to explore the effects of scale; the model should not compensate smaller companies for their lack of scale. Under the CCR model assuming economies of scale do exist, given A's scale advantage, Insurer A should be the only efficient insurer and there should be correlation between an insurer's size and its efficiency. If this trend does not exist then we should be able to conclude that there is no scale advantage in the market.

5.4 Distribution Channels

As mentioned previously there are 3 different distribution channels, the direct channel is currently emerging and at this point in time there are not enough competitors to perform an analysis, which leaves us with the Adviser and Institutional channels. These channels have different underlying cost structures and profitability so should be considered. By doing so each insurer, apart from A, operates within a single channel.

As discussed earlier, commission is paid to Advisers operating within the Adviser channel, this is a major source of cost for insurers. Each insurer will pay a different level of commission as part of their competitive offering. Commission costs are separated out, this means for the Adviser channel we have a view of efficiency including and excluding commissions. This allows us to explore the effect of commission on efficiency. We have defined the phrase "internal efficiency" to mean we are excluding commission and "total efficiency" to mean we are including commission.

5.5 Software Implementation

I used DEA.py, an implementation of DEA within Python (a programming language) using PuLP (a LP modeller written in Python) and Coin-OR (a solver accessible in Python) to solve the problem.

6 Results

6.1 Adviser

From Figure 1, we can see that Insurer A's Adviser operations are considered to be efficient by the model. However we can also see two smaller insurers G and H are considered efficient, this indicates that scale doesn't exist. The remaining insurers appear to be fairly inefficient when only internal efficiency is considered.

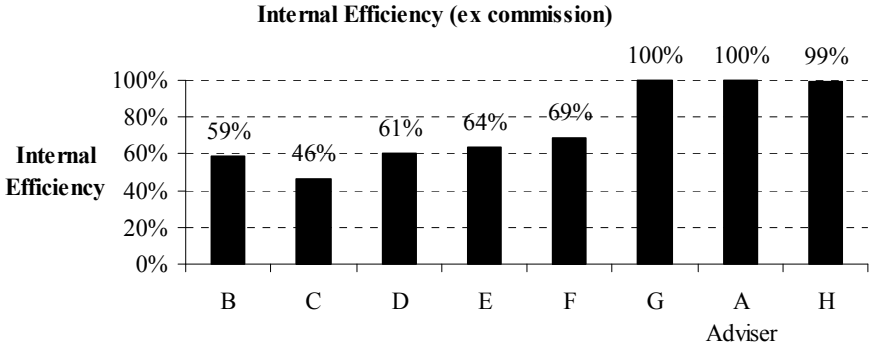

Figure 1: Internal efficiency of insurers distributing through advisers

Figure 2 shows that when commission costs are included the same insurers are considered efficient, however the efficiency of the remaining insurers improve.

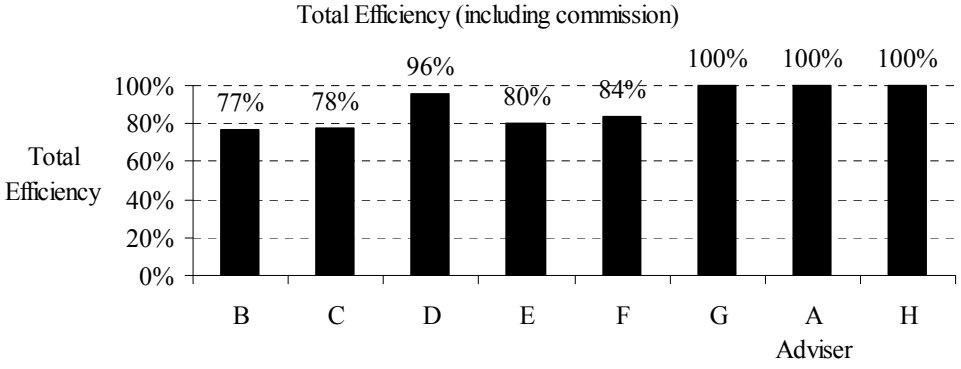

Figure 2: Total efficiency of insureres distributing through advisers

Figure 3 indicates that scale advantage doesn't exist, this is confirmed when we correlate the size of each insurer with their efficiency. A linear scale trend explained 0.0016% of the data.

An advantage of using such a simple DEA model (single input, 2 outputs) is that we can visualise our results, by normalising our outputs with respect to the input. The efficient frontier is defined in figure 4 by the grey lines. The further away an insurer is from the efficient frontier, the more inefficient it is considered.

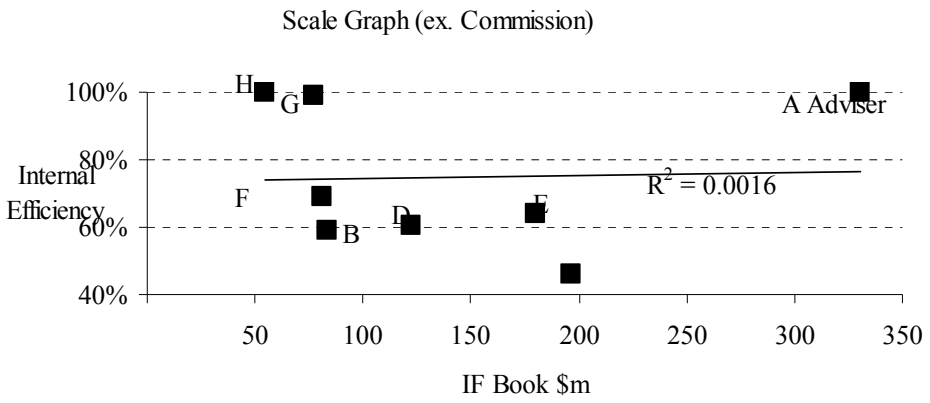

Figure 3: Scale graph for adviser channel

Internal Efficiency Frontier (ex commission)

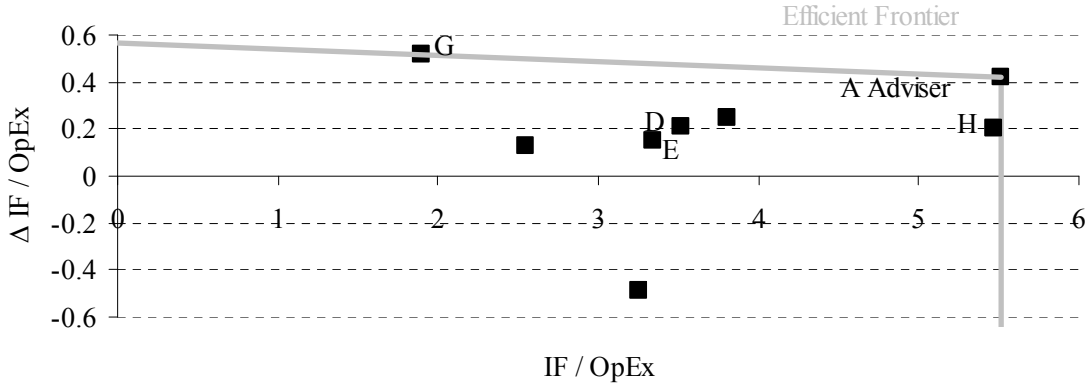

Figure 4: Internal efficiency frontier for adviser channel

What we can see from figure 4 and figure 5 is that when we include commission both Insurer A and insurer H move closer to the group of other insurers. If we were to consider super efficiency, where we allow efficiency to increase beyond 100%, we would see that Insurer A has lost super-efficiency when commission is considered. Therefore Insurer A is spending efficiency on commission.

Total Efficiency Frontier (including commission)

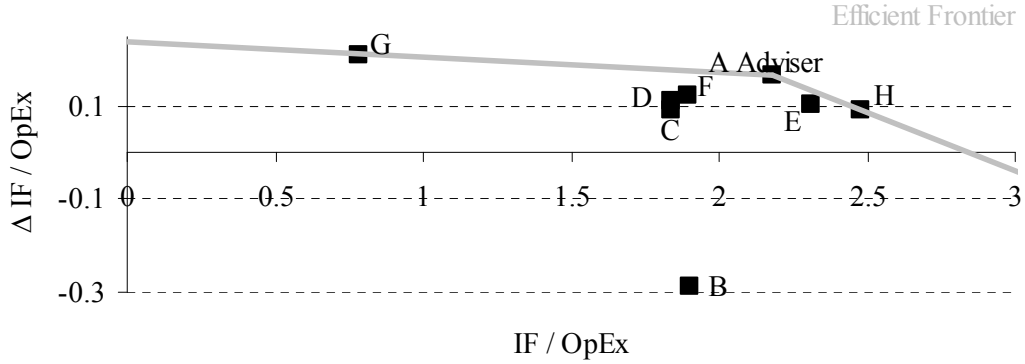

Figure 5: Total efficiency frontier for adviser channel

6.2 Institutional

Figure 6 shows that both large institutional insurers L and the institutional operations of Insurer A are considered efficient.

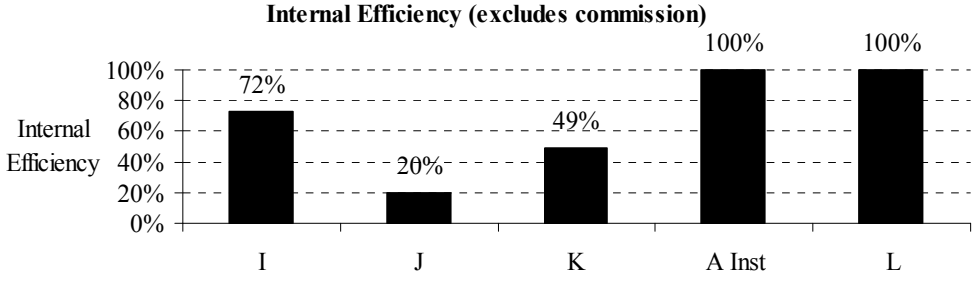

Figure 6: Internal efficiency for institutional channel

In figure 7 when we plot the size of the insurer against efficiency we find that a linear scale trend explains 65% of the data.

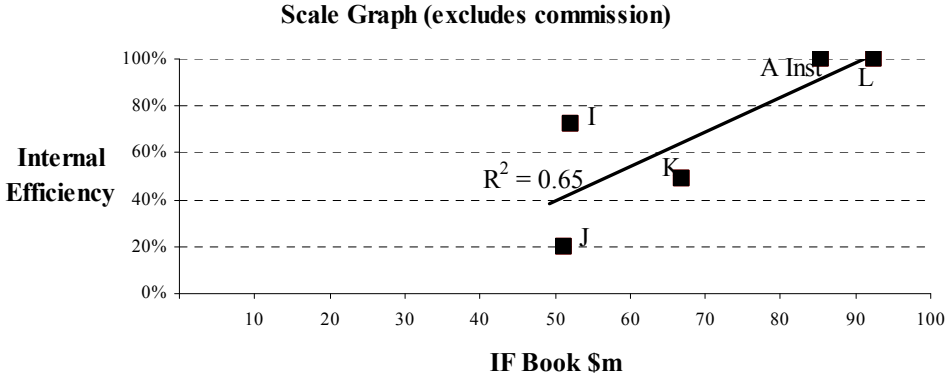

Figure 7: Scale graph for institutional channel

7 Conclusions

We have found that in the Adviser market there does not seem to be any scale advantage but there does appear to be scale advantage in the Institutional market.

Possible reasons for this difference are outlined below. The Adviser relationship is transactional as Advisers are not required to give all of their output to a single supplier, most Adviser's will choose their supplier each time they sell insurance. It may be that Adviser's value 'independence' and therefore to receive a greater share of an Adviser's business you have to offer them more than a competitor with a smaller share of their business. Or it may be a case of Insurer A not making the most of its potential scale advantage. Insurer A has grown over the years through a number of acquisitions and as a result has a number of inefficient Legacy computer systems it needs to maintain which could lead to this inefficiency.

The institutional market on the other hand is a relatively new market, most institutional business would have been written on efficient modern systems. The market that institutional is tapping into is different as well, once an insurer has signed up an institutional partner. The only insurer selling insurance to their partner's customer base is the insurer. The insurer has a monopoly on their partner's customer base. Therefore

there is no need to pay an additional premium for a large share of those customers. The result of these conclusions are;

- That Insurer A should seek to grow their institutional business by acquiring more institutional partners.
- Insurer A should not pursue a strategy of acquisitions in the Adviser channel in order to increase efficiency further.
- Insurer A should focus on increasing internal efficiency, such as resolving issues with Legacy systems.

It was also found within the Adviser channel that Insurer A is spending efficiency on commission, effectively Insurer A is paying Adviser's their efficiency instead of taking it as profit. Insurer A should review their commission structure and see if they can reduce this without reducing market share.

8 Further work

8.1 Super-efficiency

We could implement super efficiency within DEA/pu, in order to quantify the efficiency being spent on Advisers.

8.2 Malmquist Productivity Index

By implementing a Malmquist Productivity Index we can track how efficiency changes over time and track the movements of technology and A's own efficiency. This would track A's improvements in efficiency as a result of an efficiency focus within the organisation arising from this study.

8.3 Exploring the Impact of Legacy Costs

We are in the process of calculating how efficient Insurer A would be if we were to remove the costs that Legacy systems impose on the organisation. These costs are being derived from business cases to remove these Legacy systems. This will allow us to explore whether by tackling these internal inefficiencies Insurer A will be able to capture some scale advantage.

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