

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

# **Linking Increasing Returns to Industry-level Change**

A thesis presented in partial fulfillment of the requirements for the degree of

## **Doctor of Business and Administration**

in

### ***Strategy***

at Massey University, Palmerston North, New Zealand.

Mark Obren

2006

## Abstract

While the change literature is currently dominated by the punctuated equilibrium paradigm, anomalies have appeared to the paradigm in the form of high velocity change and hypercompetition. D'Aveni (1999) reconciles these anomalies with the punctuated equilibrium paradigm by suggesting that the frequency of change experienced affects the change experienced. This research considered whether the presence of increasing returns in an industry is correlated with the frequency of change experienced by the industry and the types of change that appear, thus providing an explanation for the differing forms of change.

A second observation in the literature is that an industry experiences a period of instability after a discontinuity. This research considered whether the temporal proximity or type of a preceding discontinuity influenced the likelihood or type of later discontinuities.

A longitudinal study identified discontinuities in nine industries throughout the industries' histories. The industries were categorised as: increasing returns, derived from external network effects (Airlines, Data Communications, Electricity and Shipping Lines), complementarity (Information Storage) or information content (Software), respectively; or as constant returns (Aircraft Manufacturing, Telecommunications Manufacturing and Shipbuilding). A comparison of discontinuities has been made between pairs of industries with a common end-user of the industry outputs, where one industry exhibits increasing returns and the companion industry has constant returns, using Binomial Distribution, Fisher's Exact Test and Generalised Linear Modelling techniques. Further Generalised Linear Models tested the interactions of discontinuities.

Industries with increasing returns were found to have greater frequency of change. The types of change experienced were found to affect subsequent change, with both types of discontinuities being correlated with increased proportions of competency-enhancing change for ten years, while competency-destroying and competency-

enhancing discontinuities were associated with increased frequency of change for twenty and ten years, respectively. The evidence associating increasing returns with competency type was unreliable.

Consequently, increasing returns industries may experience a greater variation of frequency of change, with industries entering and leaving periods of enhanced frequencies of change. Thus, industries with increasing returns are more likely to experience change consistent with hypercompetition and high velocity conditions, compared with the punctuated equilibrium style change experienced by constant returns industries.

## **Acknowledgements**

I would like to extend my thanks to my supervisor Ralph Stablein, for providing an appropriate level of support throughout this process and for challenging the research at key milestones. The resulting research is of a higher standard than would otherwise have been achieved without his involvement.

Second, I would like to acknowledge and thank Alisdair Noble for his guidance and knowledge in resolving the statistical methodology best suited to analyse the datasets.

I would also like to thank Bronwyn Howell for her collegial support throughout the research programme.

## Table of Contents

Abstract .....	2
Acknowledgements .....	4
Table of Contents .....	5
List of figures and tables .....	9
1. Introduction .....	14
2. Literature Review .....	18
2.1 Introduction .....	18
2.2 The Development of the early Change Literature .....	19
2.3 Change Paradigm .....	21
2.4 D’Aveni Framework .....	24
2.5 Constructs .....	26
Discontinuity .....	26
Frequency .....	29
Turbulence .....	30
Uncertainty .....	33
2.6 Increasing Returns .....	35
2.7 Gaps in Literature .....	39
2.8 Conclusion .....	42
3. Methodology .....	45
3.1 Research Strategy .....	46
Longitudinal Research .....	46
Paired Industries .....	47
Data Reliability .....	48
3.2 Data Collection .....	50
Selection .....	50
Source .....	53
Identification .....	54
Classification of Discontinuity Characteristics .....	56
Formatting .....	57
Case Studies .....	58
3.3 Data Analysis .....	59
Binomial Distribution .....	60
Fisher’s Exact Test .....	62
Generalised Linear Model .....	63
3.4 Summary .....	65
4. Results .....	66
4.1 Summary of the Data .....	66
Introduction .....	66
Sample Case Study – Shipping Lines .....	67
Sample Case Study – Shipbuilding .....	85
The Industry Datasets .....	95
Total Discontinuities .....	95
Competence-Destroying Discontinuities .....	96
Competence-Enhancing Discontinuities .....	97
Dichotomous Datasets .....	98
Summary .....	99

4.2	Testing using Binomial Distribution .....	102
	Introduction .....	102
	Test Validity .....	103
	Number of Observations .....	103
	Assumptions of the Test .....	103
	Confidence Intervals.....	105
	Summary .....	107
4.3	Testing using Fisher’s Exact Test .....	108
	Introduction .....	108
	Cross Tabulations.....	108
	Results .....	110
	Validity of Results .....	111
	Summary .....	112
4.4	Generalised Linear Model .....	113
	Introduction .....	113
	Decision Matrices.....	115
	Data Vectors .....	116
	R .....	117
	Hypothesis One .....	118
	Hypothesis Two.....	121
	Hypotheses Three-Six .....	123
	Hypothesis Three.....	124
	Hypothesis Four .....	125
	Hypothesis Five.....	126
	Hypothesis Six.....	127
4.5	Sensitivity Tests .....	128
	Hypothesis One Sensitivity Test .....	128
	Hypothesis Two Sensitivity Test.....	130
	Hypotheses Three-Six Sensitivity Tests.....	131
	Hypothesis Three Sensitivity Tests .....	132
	Hypothesis Four Sensitivity Tests.....	134
	Hypothesis Five Sensitivity Tests .....	136
	Hypothesis Five Sensitivity Test – truncated.....	138
	Hypothesis Six Sensitivity Tests .....	141
	Summary .....	143
5.	Discussion.....	153
	5.1 Introduction .....	153
	5.2 Results .....	153
	5.3 Linking into the Literature .....	154
	5.4 Considerations for further research .....	157
6	Conclusion .....	161
Appendices.....		164
Case Study: Airline Industry.....		166
	Introduction .....	166
	Industry Background.....	166
	Industry’s Key Performance Parameter .....	167

Discontinuities .....	168
Nature of the Discontinuities .....	171
Conclusion .....	172
Bibliography .....	173
Case Study: Aircraft Manufacturing Industry.....	174
Introduction.....	174
Industry Background.....	174
Industry's Key Performance Parameter .....	175
Discontinuities .....	175
Nature of the Discontinuities .....	177
Conclusion .....	177
Bibliography .....	178
Case Study: Data Communications Industry .....	179
Introduction.....	179
Industry Background.....	179
Industry's Key Performance Parameter .....	180
Discontinuities .....	181
Network .....	181
Transmission Equipment.....	183
Nature of the Discontinuities .....	186
Conclusion .....	189
Bibliography .....	190
Case Study: Telecommunications Manufacturing Industry.....	194
Introduction.....	194
Industry Background.....	194
Industry's Key Performance Parameter .....	196
Discontinuities .....	196
Nature of the Discontinuities .....	200
Conclusion .....	201
Bibliography .....	202
Case Study: Electricity Generation .....	204
Introduction.....	204
Industry Background.....	204
Industry's Key Performance Parameter .....	205
Discontinuities .....	205
Conclusion .....	212
Bibliography .....	213
Case Study: Shipping Lines .....	216
Introduction.....	216
Industry Background.....	216
Industry's Key Performance Parameter .....	217
Discontinuities .....	218
Nature of the Discontinuities .....	226
Conclusion .....	228
Bibliography .....	229
Case Study: Shipbuilding Industry .....	234
Introduction.....	234
Industry Background.....	234
Industry's Key Performance Parameter .....	235
Discontinuities .....	235

Nature of the Discontinuities .....	239
Conclusion .....	240
Bibliography .....	241
Case Study: Software Industry.....	244
Introduction.....	244
Industry Background.....	245
Industry’s Key Performance Parameter.....	245
Discontinuities .....	246
Nature of the Discontinuities .....	251
Conclusion .....	253
Bibliography .....	254
Case Study: Information Storage Industry.....	255
Introduction.....	255
Industry Background.....	255
Industry’s Key Performance Parameter .....	256
Discontinuities .....	257
Nature of the Discontinuities .....	261
Conclusion .....	263
Bibliography .....	264
Data .....	266
DataSets .....	266
Total Discontinuities .....	266
Competence-Destroying Discontinuities.....	271
Competence-Enhancing Discontinuities .....	276
Dichotomous Datasets .....	281
Total Discontinuities - Dichotomous .....	281
Competence-Destroying Discontinuities - Dichotomous.....	286
Competence-Enhancing Discontinuities – Dichotomous.....	291
Decision Matrices .....	296
Decision Matrix.....	296
First Extended Decision Matrix .....	298
Second Extended Decision Matrix .....	300
GLM Data Vectors.....	302
0-10 year and 11-20 year Data Vectors.....	302
0-8 year and 9-16 year Data Vectors.....	316
0-11 year and 12-22 year Data Vectors.....	330
Results.....	344
GLM Results.....	344
GLM Results – Hypothesis One.....	344
GLM Results – Hypothesis Two .....	346
GLM Results – Hypotheses Three to Six .....	348
GLM Results – Hypothesis One Sensitivity Tests .....	351
GLM Results – Hypothesis Two Sensitivity Tests .....	354
GLM Results – Hypotheses Three to Six Sensitivity Tests .....	358
GLM Results – Hypothesis Five Sensitivity Tests - Truncated .....	362
Bibliography .....	368
Reference List.....	368
Case Study Bibliography .....	379
Index .....	394

## List of figures and tables

Figure 1: The D’Aveni Framework .....	24
Figure 2: Transilience Map .....	27
Figure 3: Standard Error .....	61
Table 1: Shipping Technologies Discontinuities 1807-2005.....	78
Table 2: Frequency of change of Shipping Industry .....	79
Table 3: Shipbuilding Industry Discontinuities 1807-2003.....	91
Table 4: Sample Period of Total Discontinuities.....	95
Table 5: Sample Period of Competence-Destroying Discontinuities .....	96
Table 6: Sample Period of Competence-Enhancing Discontinuities .....	97
Table 7: Summary of Discontinuity Datasets .....	99
Table 8: Summary of Dichotomous Datasets .....	100
Table 9: Industry discontinuity distribution.....	101
Table 10: Number of Observations.....	103
Table 11: Values of $Np$ , $N(1-p)$ and $p$ .....	104
Table 12: Confidence Intervals.....	105
Table 13: Airlines/Aircraft Manufacturing Cross tabulation.....	109
Table 14: Data Communications/Telecommunications Manufacturing Cross tabulation.....	109
Table 15: Electricity/Shipbuilding Cross tabulation.....	109
Table 16: Shipping Lines /Shipbuilding Cross tabulation .....	109
Table 17: Fisher’s Exact Test .....	110
Table 18: Fisher’s Exact Test Expected Counts .....	111
Table 19: Sample Vector .....	116
Table 20: GLM results – Hypothesis One .....	118
Table 21: Truncated GLM - Hypothesis One .....	119
Table 22: GLM results – Hypothesis Two.....	121
Table 23: Truncated GLM – Hypothesis Two.....	122
Table 24: GLM results – Hypothesis Three.....	124
Table 25: GLM results – Hypothesis Four .....	125
Table 26: GLM results – Hypothesis Five.....	126
Table 27: GLM results – Hypothesis Six.....	127
Table 28: GLM results – Hypothesis One (8/16 years) .....	128
Table 29: GLM results – Hypothesis One (11/22 years) .....	129
Table 30: GLM results – Hypothesis Two 8/16 years .....	130
Table 31: GLM results – Hypothesis Two 11/2 years .....	130
Table 32: GLM results – Hypothesis Three 8/16 years .....	132
Table 33: GLM results – Hypothesis Three 11/22 years .....	132
Table 34: GLM results – Hypothesis Four 8/16 years .....	134
Table 35: GLM results – Hypothesis Four 11/22 years .....	134
Table 36: GLM results – Hypothesis Five – 8/16 years .....	136
Table 37: GLM results – Hypothesis Five – 11/22 years .....	136
Table 38: GLM results – Hypothesis Five – 8/16 years, truncated .....	138
Table 39: GLM results – Hypothesis Five – 10/20 years, truncated .....	139
Table 40: GLM results – Hypothesis Five – 11/22 years, truncated .....	139
Table 41: GLM results – Hypothesis Six 8/16 years .....	141
Table 42: GLM results – Hypothesis Six 11/22 years .....	141

Table 43: Summary Hypothesis One sensitivity tests, $\Pr(> z )$ .....	143
Table 44: Summary Hypothesis Two sensitivity tests, $\Pr(> z )$ .....	144
Table 45: Summary Hypothesis Three sensitivity tests, $\Pr(> z )$ .....	145
Table 46: Summary Hypothesis Four sensitivity tests, $\Pr(> z )$ .....	147
Table 47: Summary Hypothesis Five sensitivity tests, $\Pr(> z )$ .....	148
Table 48: Summary Hypothesis Five sensitivity tests, truncated decision matrix, $\Pr(> z )$ .....	149
Table 49: Summary Hypothesis Six sensitivity tests, $\Pr(> z )$ .....	150
Table 50: Airline Discontinuities 1919-2003 .....	171
Table 51: Aircraft Manufacturing Industry Discontinuities 1919-2003.....	177
Table 52: Data Communications Network Discontinuities 1791-2003.....	187
Table 53: Frequency of change of data communications transmission equipment 1791-2003 .....	189
Table 54: Data Communications Industry Discontinuities 1791-2003.....	200
Table 55: Electricity Generation Technological Discontinuities 1870-2003. ....	211
Table 56: Shipping Technologies Discontinuities 1807-2005.....	227
Table 57: Frequency of change of Shipping Industry.....	228
Table 58: Shipbuilding Industry Discontinuities 1807-2003.....	240
Table 59: Software Discontinuities 1890-2003. ....	252
Table 60: Frequency of change of software industry 1890-2003 .....	253
Table 61: Information Storage Discontinuities 1890-2002. ....	262
Table 62: Frequency of change of software industry 1890-2003 .....	263
Table 63: Total Discontinuities.....	266
Table 64: Competence-Destroying Discontinuities .....	271
Table 65: Competence-Enhancing Discontinuities.....	276
Table 66: Total Discontinuities - dichotomous.....	281
Table 67: Competence-Destroying Discontinuities - dichotomous.....	286
Table 68: Competence-Enhancing Discontinuities.....	291
Table 69: Decision Matrix .....	296
Table 70: First Extended Decision Matrix.....	298
Table 71: Second Extended Decision Matrix .....	300
Table 72: Airlines/Aircraft Manufacturing Vector .....	302
Table 73: Data Communications/Telecommunications Manufacturing Vector .....	304
Table 74: Electricity/Ship Building Vector .....	306
Table 75: Shipping Lines/Ship Building Vector.....	308
Table 76: Total Industry Pairs Vector.....	310
Table 77: Paired Industries Vector .....	312
Table 78: Total Increasing Returns Industries/Total Constant Returns Industries Vector.....	314
Table 79: Airlines/Aircraft Manufacturing Vector .....	316
Table 80: Data Communications/Telecommunications Manufacturing Vector .....	318
Table 81: Electricity/Ship Building Vector .....	320
Table 82: Shipping Lines/Ship Building Vector.....	322
Table 83: Total Industry Pairs Vector.....	324
Table 84: Paired Industries Vector .....	326
Table 85: Total Increasing Returns Industries/Total Constant Returns Industries Vector.....	328
Table 86: Airlines/Aircraft Manufacturing Vector .....	330
Table 87: Data Communications/Telecommunications Manufacturing Vector .....	332
Table 88: Electricity/Ship Building Vector .....	334

Table 89: Shipping Lines/Ship Building Vector.....	336
Table 90: Total Industry Pairs Vector.....	338
Table 91: Paired Industries Vector .....	340
Table 92: Total Increasing Returns Industries/Total Constant Returns Industries Vector.....	342
Table 93: Airlines/Aircraft Manufacturing GLM .....	344
Table 94: Data Communications/Telecommunications Manufacturing GLM .....	344
Table 95: Electricity/Shipbuilding GLM.....	344
Table 96: Shipping Lines/Shipbuilding GLM .....	345
Table 97: Total Industry Pairs GLM.....	345
Table 98: Paired Industries GLM .....	345
Table 99: Total Increasing Returns/Total Constant Returns Industries GLM.....	345
Table 100: Airlines/Aircraft Manufacturing GLM – first extended matrix.....	346
Table 101: Data Communications/Telecommunications Manufacturing GLM – first extended matrix.....	346
Table 102: Electricity/Shipbuilding GLM- first extended matrix .....	347
Table 103: Shipping Lines/Shipbuilding GLM – first extended matrix .....	347
Table 104: Total Industry Pairs GLM- first extended matrix .....	347
Table 105: Airlines/Aircraft Manufacturing GLM – second extended matrix .....	348
Table 106: Data Communications/Telecommunications Manufacturing GLM – second extended matrix.....	348
Table 107: Electricity/Shipbuilding GLM- second extended matrix.....	349
Table 108: Shipping Lines/Shipbuilding GLM – second extended matrix .....	349
Table 109: Paired Industries GLM – second extended matrix .....	349
Table 110: Total Increasing Returns/Total Constant Returns Industries GLM – second extended matrix.....	350
Table 111: Airlines/Aircraft Manufacturing GLM (8/16 years).....	351
Table 112: Airlines/Aircraft Manufacturing GLM (11/22 years).....	351
Table 113: Data Communications/Telecommunications Manufacturing GLM (8/16 years).....	351
Table 114: Data Communications/Telecommunications Manufacturing GLM (11/22 years).....	352
Table 115: Electricity/Shipbuilding GLM (8/16 years).....	352
Table 116: Electricity/Shipbuilding GLM (11/22 years).....	352
Table 117: Shipping Lines/Shipbuilding GLM (8/16 years) .....	353
Table 118: Shipping Lines/Shipbuilding GLM (11/22 years).....	353
Table 119: Total Industry Pairs GLM (8/16 years) .....	353
Table 120: Total Industry Pairs GLM (11/22 years) .....	353
Table 121: Airlines/Aircraft Manufacturing GLM – first extended matrix (8/16 years) .....	354
Table 122: Airlines/Aircraft Manufacturing GLM – first extended matrix (11/22 years).....	354
Table 123: Data Communications/Telecommunications Manufacturing GLM – first extended matrix (8/16 years) .....	355
Table 124: Data Communications/Telecommunications Manufacturing GLM – first extended matrix (11/22 years) .....	355
Table 125: Electricity/Shipbuilding GLM- first extended matrix (8/16 years) .....	355
Table 126: Electricity/Shipbuilding GLM- first extended matrix (11/22 years) .....	356
Table 127: Shipping Lines/Shipbuilding GLM – first extended matrix (8/16 years)	356

Table 128: Shipping Lines/Shipbuilding GLM – first extended matrix (11/22 years)	356
Table 129: Total Industry Pairs GLM- first extended matrix (8/16 years)	357
Table 130: Total Industry Pairs GLM- first extended matrix (11/22 years)	357
Table 131: Airlines/Aircraft Manufacturing GLM – second extended matrix (8/16 years)	358
Table 132: Airlines/Aircraft Manufacturing GLM – second extended matrix (11/22 years)	358
Table 133: Data Communications/Telecommunications Manufacturing GLM – second extended matrix (8/16 years)	358
Table 134: Data Communications/Telecommunications Manufacturing GLM – second extended matrix (11/22 years)	359
Table 135: Electricity/Shipbuilding GLM- second extended matrix (8/16 years)	359
Table 136: Electricity/Shipbuilding GLM- second extended matrix (11/22 years)	359
Table 137: Shipping Lines/Shipbuilding GLM – second extended matrix (8/16 years)	360
Table 138: Shipping Lines/Shipbuilding GLM – second extended matrix (11/22 years)	360
Table 139: Paired Industries GLM – second extended matrix (8/16 years)	360
Table 140: Paired Industries GLM – second extended matrix (11/22 years)	361
Table 141: Total Increasing Returns/Total Constant Returns Industries GLM – second extended matrix (8/16 years)	361
Table 142: Total Increasing Returns/Total Constant Returns Industries GLM – second extended matrix (11/22 years)	361
Table 143: Airlines/Aircraft Manufacturing GLM – second extended matrix, truncated (10/20 years)	362
Table 144: Airlines/Aircraft Manufacturing GLM – second extended matrix, truncated (8/16 years)	362
Table 145: Airlines/Aircraft Manufacturing GLM – second extended matrix, truncated (11/22 years)	362
Table 146: Data Communications/Telecommunications Manufacturing GLM – second extended matrix, truncated (10/20 years)	362
Table 147: Data Communications/Telecommunications Manufacturing GLM – second extended matrix, truncated (8/16 years)	363
Table 148: Data Communications/Telecommunications Manufacturing GLM – second extended matrix, truncated (11/22 years)	363
Table 149: Electricity/Shipbuilding GLM- second extended matrix, truncated (10/20 years)	364
Table 150: Electricity/Shipbuilding GLM- second extended matrix, truncated (8/16 years)	364
Table 151: Electricity/Shipbuilding GLM- second extended matrix, truncated (11/22 years)	364
Table 152: Shipping Lines/Shipbuilding GLM – second extended matrix, truncated (10/20 years)	365
Table 153: Shipping Lines/Shipbuilding GLM – second extended matrix, truncated (8/16 years)	365
Table 154: Shipping Lines/Shipbuilding GLM – second extended matrix, truncated (11/22 years)	365
Table 155: Paired Industries GLM – second extended matrix, truncated (10/20 years)	366

Table 156: Paired Industries GLM – second extended matrix, truncated (8/16 years)	366
Table 157: Paired Industries GLM – second extended matrix, truncated (11/22 years)	366
Table 158: Total Increasing Returns/Total Constant Returns Industries GLM – second extended matrix, truncated (10/20 years)	367
Table 159: Total Increasing Returns/Total Constant Returns Industries GLM – second extended matrix, truncated (8/16 years)	367
Table 160: Total Increasing Returns/Total Constant Returns Industries GLM – second extended matrix, truncated (11/22 years)	367