



JDA Software Group, Inc.

Estimating Price Sensitivity when Prices are Determined Endogenously

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Portfolio *Enabled*

Agenda

- Introductions
- Why do we care about elasticity?
- What do we mean by 'endogenous prices'?
- A simple spreadsheet experiment
- Recommendations for effective price elasticity estimation

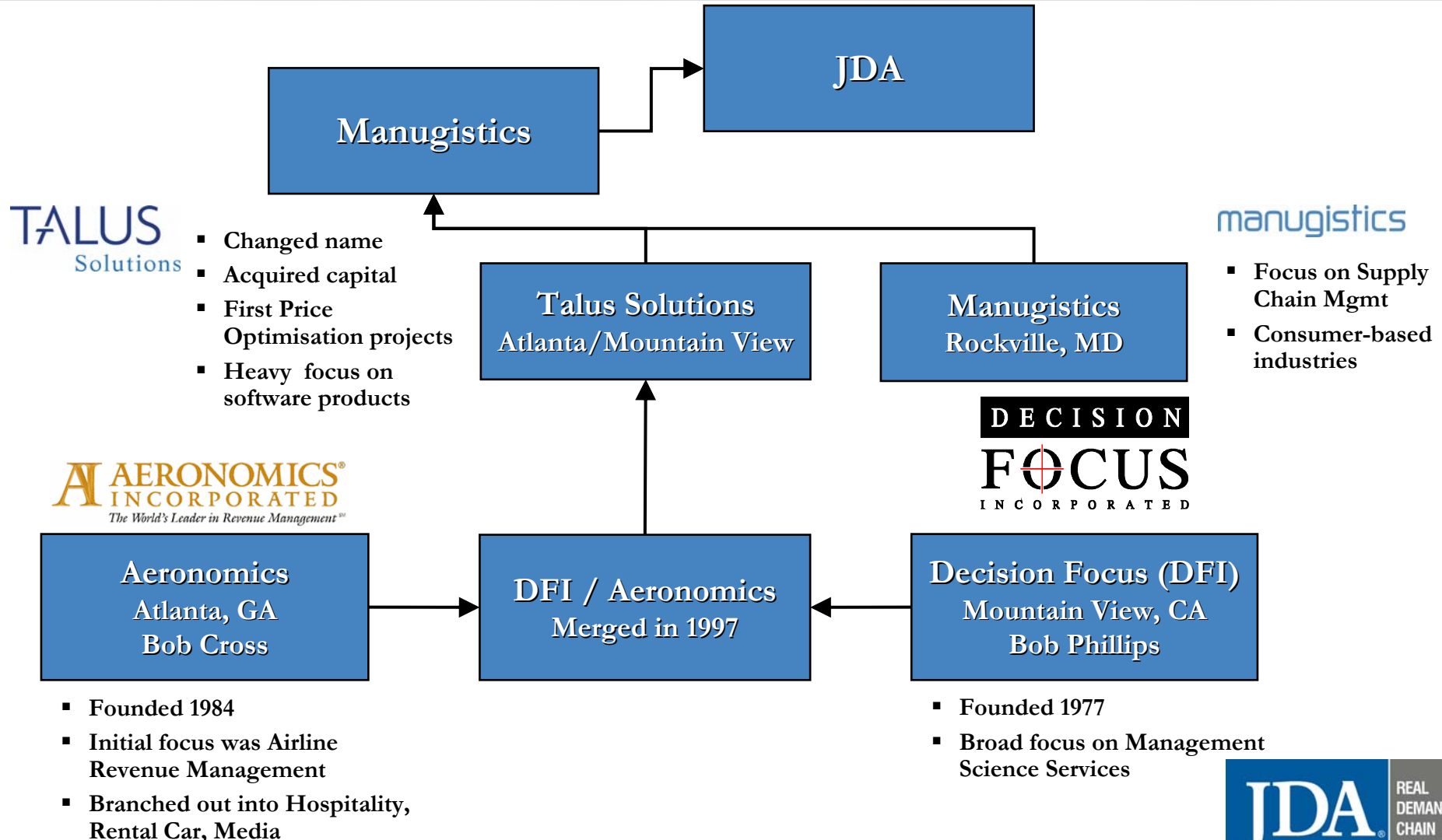
Brief Introduction to Bob Garner

Mathematics / Operational Research / Economics

- Key Dates:
 - Born, February 1960
 - Joined BA as Operational Research Analyst, November 1982
 - Joined BA COBRA Project, November 1989
 - Leg optimisation / Point of Sale / Early O&D studies
 - Studied Mandarin Chinese in Beijing, October 1996 to February 1997
 - Joined Talus (DFI-Aeronomics), February 1998
 - Focus on Air Cargo RM / Passenger O&D / Hotel RM
 - (Re) joined Manugistics, August 2001
 - Tour Operator RM
 - Price Sensitive Revenue Management
 - ‘Low Cost’ Airlines and International Passenger Rail
 - Various Retail and CPG Price and Promotions Optimisation Projects
 - Transferred to Asia Pacific
 - Business Development (Hong Kong), July 2005
 - Relocated to Shanghai, March 2006
 - Manugistics acquired by JDA, June 2006

JDA's Pricing & Revenue Management Heritage

20+ Years of Experience



JDA in Asia

- 12 years in Asia
- Offices
 - Singapore (Regional HQ)
 - Shanghai, Tokyo, Sydney, Melbourne, India
- 270 Customers
- 488 product installations
- Over 100 JDA associates



Why do we care about estimating elasticity?

- The success of so-called low cost airlines and increased use of the Internet as a sales channel has lead to simplified fare structures
- This in turn has lead to a move away from optimisation by availability management towards price optimisation
 - Price Sensitive Revenue Management
- Similar business models have now been adopted by most of the majority network airlines
- And increasingly in other industries
 - Tour Operators
 - Train Operators
 - Hotels

What Do We Mean by Endogenous Prices?

- Prices are set and regularly reviewed on a flight by flight (train by train, hotel night by hotel night) basis by an intelligent person or system based on the perceived level of underlying demand so that observed prices are a function of underlying demand (level and sensitivity) and its relationship to available capacity

(Why) Do Endogenous Prices Matter?

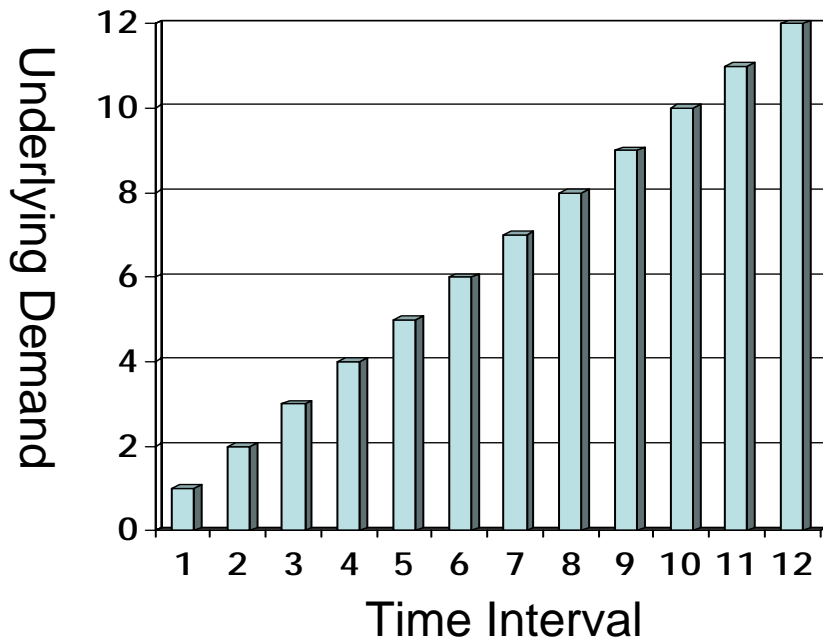
- If Prices are set endogenously then the relationship between observed demand and price may be downward sloping, flat, or even upwards sloping
- Experience has shown us that price elasticity coefficients estimated using Linear Regression are often counter-intuitive
 - Price often does not appear to be a significant driver of demand
 - Is this really true?
 - When price is a significant driver of demand the price coefficient is as likely to be positive as negative
 - Does this really mean that demand increases as prices go up?!

A Desktop Experiment

- A problem with working with real data is that we cannot know the true elasticity so it is difficult to judge the accuracy of our results
- The approach taken is to construct a set of artificial data with known properties then try to recover these properties using a linear regression model

A Desktop Experiment

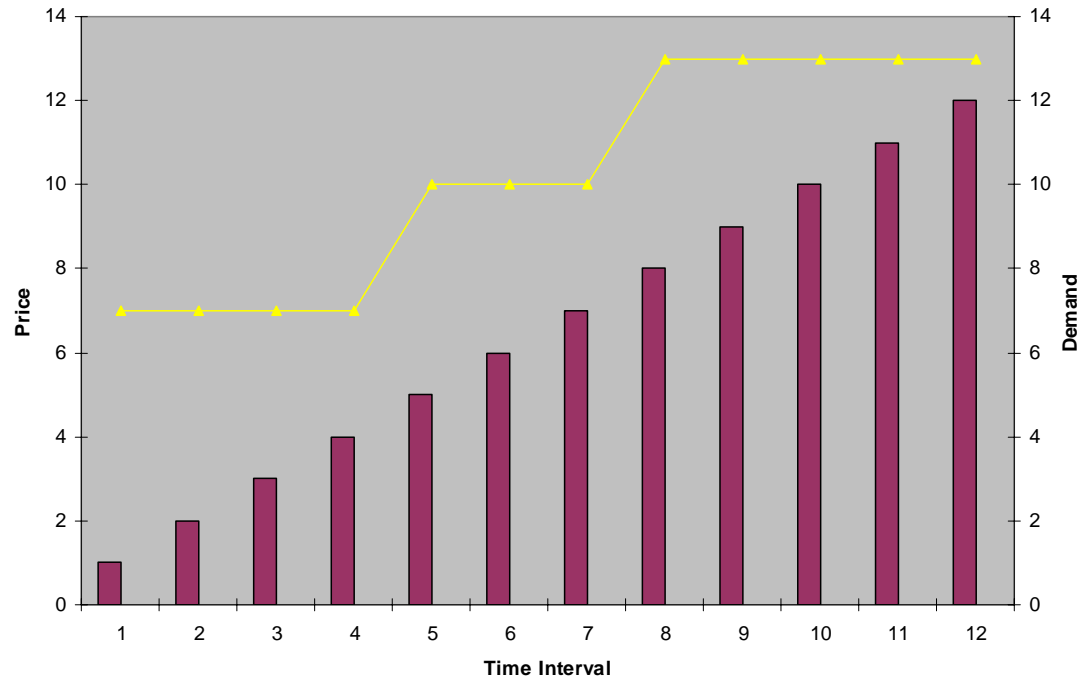
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- There are 12 Seasonality Periods
- Mean underlying demand in Period i is equal to i
 - A random element has been added
- Demand is Constant Elasticity
 - Price Elasticity is -1.5
- Reference Price is 10
- There are 10 sets of data
- The Price Setter understood underlying demand and has used a simple rule of thumb to set prices

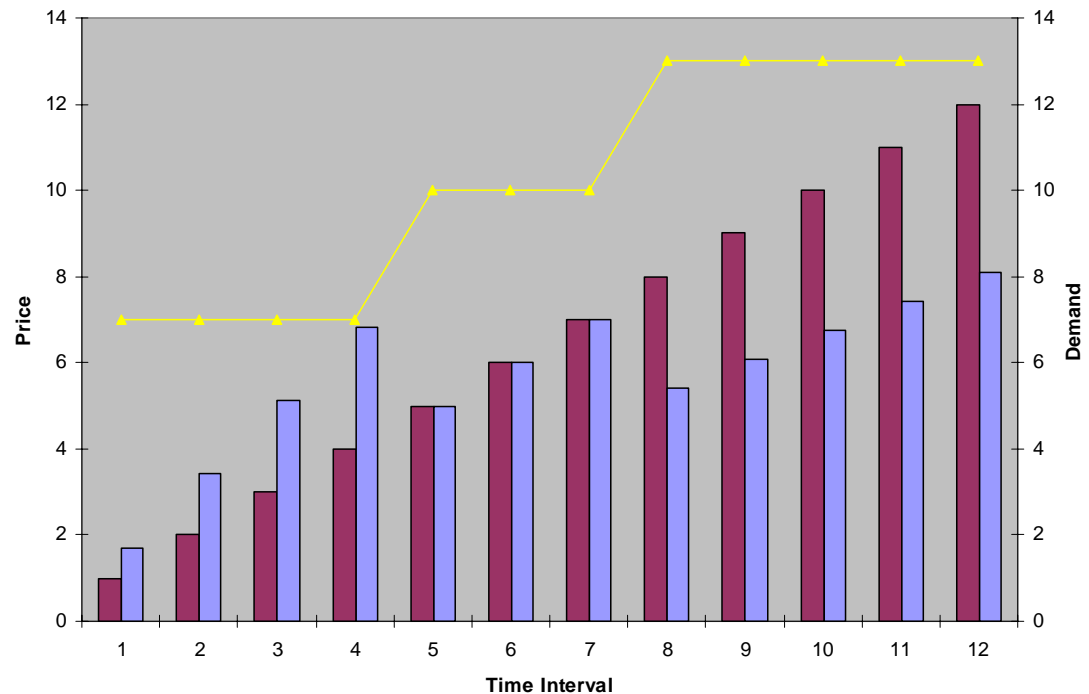
A Pricing Rule

- If underlying demand is less than or equal to 4 price is set equal to 7
- Otherwise, if Underlying demand is greater than or equal to 8 price is set equal to 13
- Otherwise, price is set equal to 5



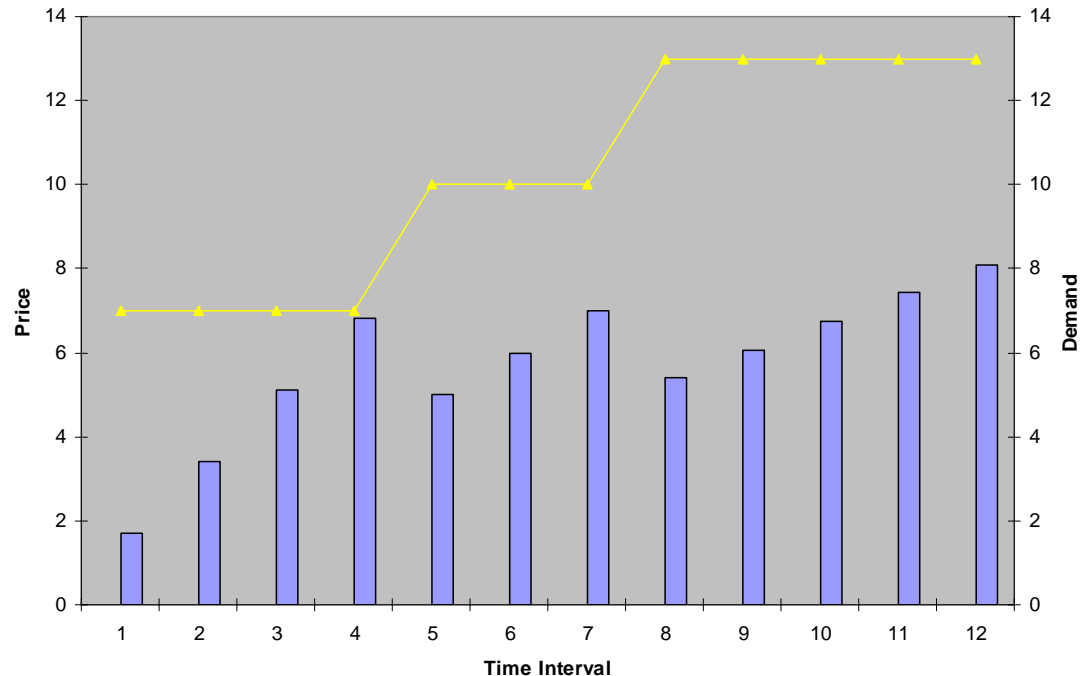
A Pricing Rule

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A Pricing Rule

- If underlying demand is less than or equal to 4 price is set equal to 7
- Otherwise, if Underlying demand is greater than or equal to 8 price is set equal to 13
- Otherwise, price is set equal to 5



Result 1

If the pricing rule is followed rigorously

- If the pricing rule is always followed then estimated elasticity is zero
 - And seasonal coefficients equate to observed demand

	m	1	2	3	4	5	6	7	8	9	10	11	12
Coefficient	0	1.61	3.24	5.42	7.16	5.03	6.06	7.13	5.67	6.40	6.68	7.39	7.76
SE	0.0000	0.0369	0.0369	0.0369	0.0369	0.0369	0.0369	0.0369	0.0369	0.0369	0.0369	0.0369	0.0369

- This occurs because price is completely determined by the seasonality coefficients

Result 2

If some random price variation has occurred

- If the pricing rule is followed but with some deviation then estimated elasticity is close to -1.5
 - And seasonal coefficients equate to underlying demand

	m	1	2	3	4	5	6	7	8	9	10	11	12
Coefficient	-1.51	0.94	1.89	3.16	4.17	5.03	6.06	7.13	8.44	9.52	9.94	10.99	11.55
SE	0.3460	0.1288	0.1288	0.1288	0.1171	0.0370	0.0370	0.0370	0.0980	0.0980	0.0980	0.0980	0.0980

- Only one non-seasonal price variant data point is required to get this result
- If the number of non-seasonal price variant point is small then the result can be volatile
 - But estimate should be unbiased

Why Do We Get Counter-Intuitive Results in Practice?

Why Do We Get Counter-Intuitive Results in Practice?

- Suppose that our Demand Planner / Revenue Management Executive is cleverer than our Statistician
 - Or at least that she knows more about underlying demand at a day to day level
- There may be numerous special events that are not captured by the models seasonality variables and yet the price has been adjusted accordingly

Result 3

If there are special events that have been recognized by the price setter

- If there are special events which are known to the pricing executive but not known to the model
 - Estimates elasticity is generally damped and may show the wrong sign

	m	1	2	3	4	5	6	7	8	9	10	11	12
Coefficient	2.24	3.49	7.21	12.06	15.93	5.03	6.06	7.13	3.15	3.55	3.71	4.10	4.31
SE	0.1959	0.0682	0.0782	0.0782	0.0782	0.0364	0.0364	0.0364	0.0630	0.0630	0.0630	0.0630	0.0630

- If these events are large enough to trigger price changes then they look like random price variation to the model
- The effect is potentially made amplified by the absence or scarcity of true non-seasonal random price variant data points

Some Other Potential Causes

- Incorrectly specified seasonality
 - The 12 ‘monthly’ seasonal dummy variables were replaced with 4 ‘seasonal’ seasonal dummy variables
 - The estimated elasticity to be ‘damped’ but the coefficient remains significant and the sign is correct (negative)
- Incorrect functional form
 - The underlying model used to generate data was replaced by a linear model but a log model is again used to estimate elasticity
 - Estimated elasticity has the wrong sign (positive)

Conclusions

- Using this simple spreadsheet experiment we have shown that provided we have a correctly specified model and that there is sufficient random price variation then the fact that prices are determined endogenously does not prevent us from accurately estimating price elasticity
 - Nor does it explain the counter-intuitive results that are common in practice
- Lack of random price variation and the presence of demand special events not captured by the model are more likely account for these results
- Incorrect functional form may also cause estimated elasticity coefficients to be counter intuitive

Recommendations

- Clean and segment data carefully
- Use micro level data / try to avoid using average prices
 - Mask true price and demand variation
 - Can introduce spurious price variation
- Focus attention where there is non-seasonal price variation where possible
- Carefully identify and neutralize any special events not fully captured by seasonality
 - Build them onto the model
 - Mask or remove data from the regression
- **Introduce non-seasonal price variation where necessary**
- Always check functional form assumptions