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# FORECASTING PHARMACEUTICAL LIFE CYCLES: A CASE STUDY OF HOW PHARMACEUTICALS ARE PRESCRIBED IN THE NHS IN THE UK

By Samantha Buxton  
Dr Marwan Khammash  
Professor Philip Stern

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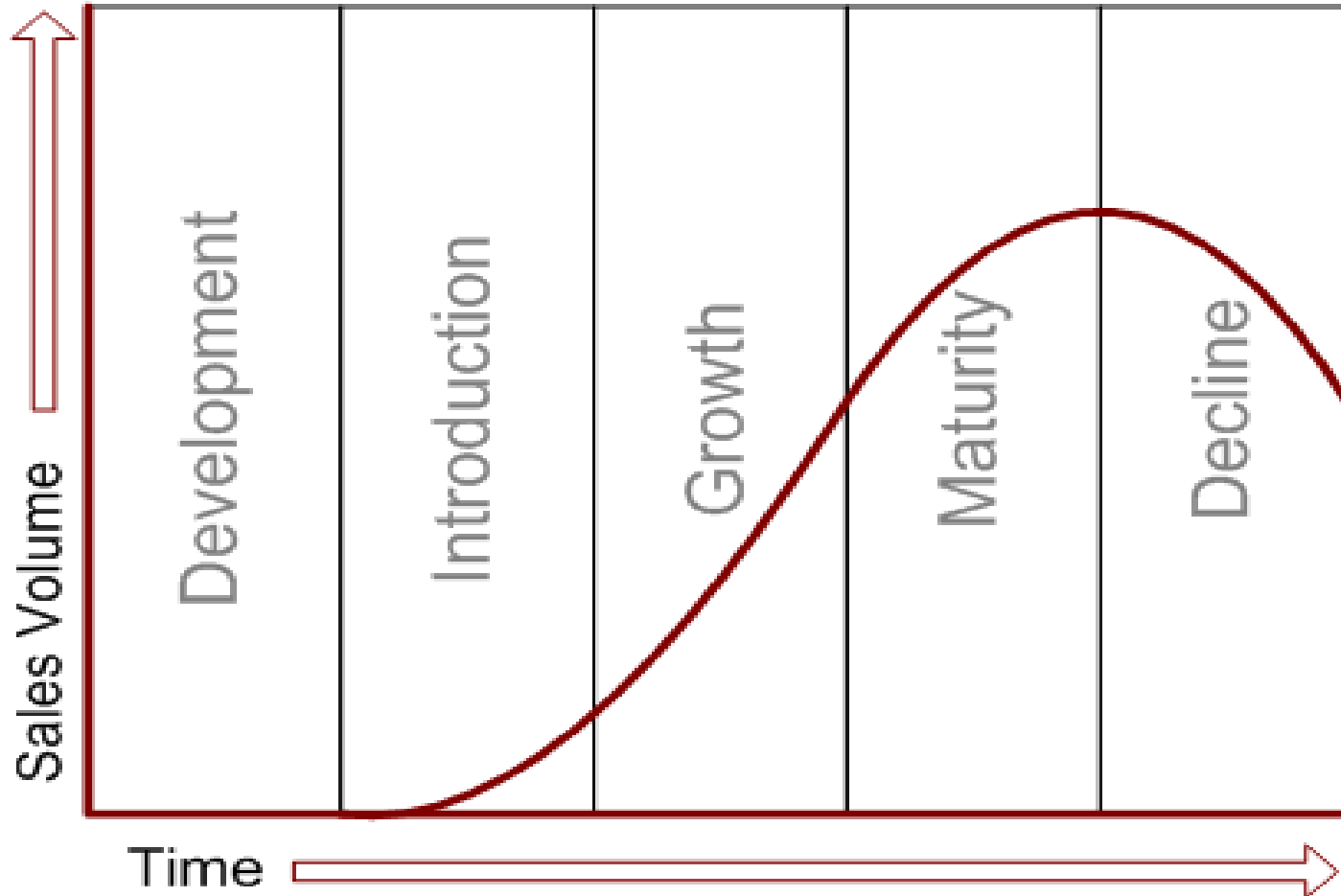
Professor Kostas Nikolopoulos

# PRESENTATION STRUCTURE

- Previous Research – Product Lifecycle
- Pharmaceutical Market
- Research Project – Aims
- Research Project - The Data
- Preliminary Results
- Graph Categories
- Next Steps



# PREVIOUS RESEARCH – PRODUCT LIFE CYCLE



# PHARMACEUTICAL MARKET

- Moss (2008) states that research has focused on consumer products and brands disregarding other products and brands such as pharmaceuticals.
- Highly competitive non assembled global industry
- In 2007 the top 10 pharmaceutical companies had a combined sales of just under £150 billion and commanded 45% market share
- 2 of these were UK companies – AstraZeneca and GlaxoSmithKline



# PHARMACEUTICAL MARKET CONTINUED

- In 2008 £4 billion was spent on R&D however this was expected to decrease due to the financial climate
- Patent Expiration – Major Problem
- UK patents last for 20 years from application
- 5 year extension can be applied for
- Generics enter the market
- NHS and other health/government organisations always looking at ways to curb the rising cost of healthcare



# PHARMACEUTICAL MARKET CONTINUED

- A branded drug is one made by a specific pharmaceutical company and is therefore given a name. The generic is the key compound that makes up the drug. In some cases the company can market both the branded and generic to appeal to a wider audience. An example is Sertraline.
- Brand name – Lustral by Pfizer
- Generic name – Sertraline.



# RESEARCH PROJECT - AIMS

## ○ Aims

1. To classify the patterns that are exhibited during the product lifecycle of pharmaceutical drugs
2. Model these patterns
3. Forecast the patterns
4. This will allow us to discover which forecasting methods forecast the lifecycle better depending on the different stages
  1. Introduction
  2. Growth
  3. Maturity
  4. Decline





# RESEARCH PROJECT – THE DATA

- JIGSAW database
- Established in 1985 by ISIS research for the purposes of academic research
- Data from 1987 -2008
- 2.57 million script records
- Self Report Questionnaires from GP's
- Data is specifically relating to what drugs are prescribed



# PHARMACEUTICAL LIFE CYCLE TYPES

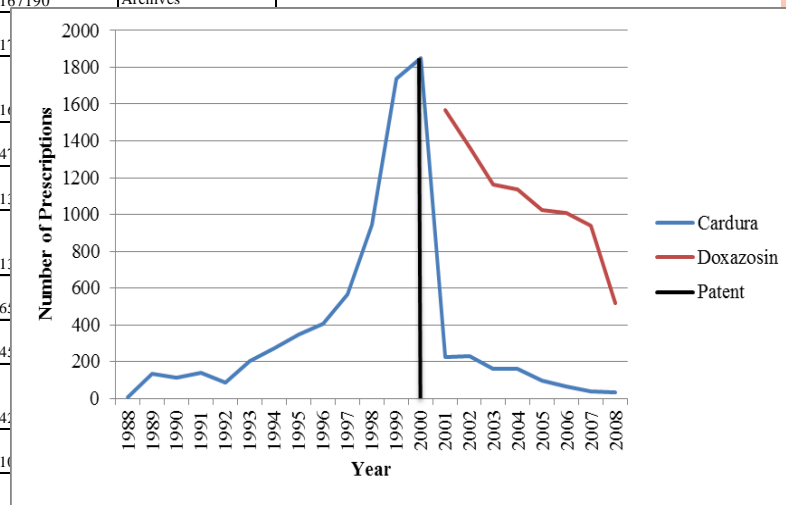


- Based on the current research there are three types of pharmaceutical life cycle including both a branded and a generic strand.
- Branded then Generic
- High Branded Low Generic
- High Generic Low Branded



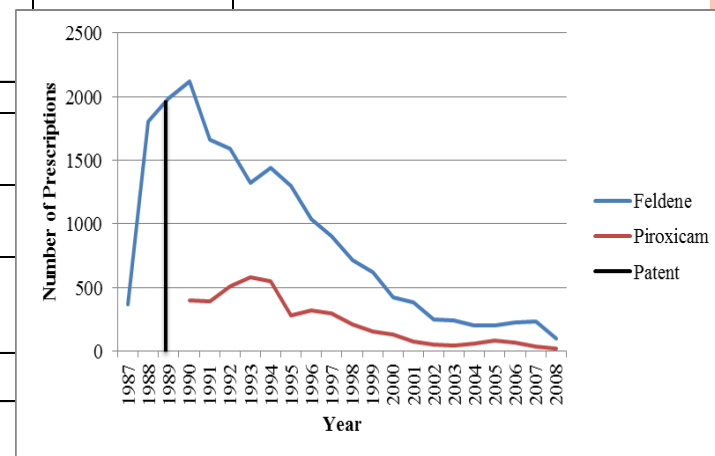
# BRANDED THEN GENERIC

Branded Drug	Generic Drug	Therapeutic Class	CAS Number	Patent Number	Patentee	Year of Patent Granted	Year of Patent Expiration	Supplementary Protection Certificate (SPC)	Total Number of Prescriptions (Rx) between 1987 and 2008	Sources
Cardura	Doxazosin	Hypertension	74191-85-8	US4188390	Pfizer	1980	2000	NA	17990	Merck Index, Espacenet
Defacac	Diclofenac	Anti-inflammatory	13307-86-5	GB 1132318	Geigy	1968	1983	NA	167190	Espacenet, Patent Archives
Gamanil	Lofepamine	Anti-depressant	23047-25-8	GB 1177525	Leo	1970	1984	NA	11	
Innovace	Enalapril	Angiotensin Converting Enzyme (ACE)	7475847-73-3	EP12401	Merck and Co	1983	1995	NA	16	
Losec	Omeprazole	Acid Reflux	73590-58-6	EP5129	Haessle AB	1979	1999	2005	47	
Lustral	Sertraline	Anti-depressant	79617-96-2	EP 30081	Pfizer	1981	2000	2005	11	
Mobic	Meloxicam	Analgesic/Anti-inflammatory	71125-38-7	EP0002482	Boehringer Ingelheim	1979	1998	2003	11	
Naprosyn	Naproxen	Anti-inflammatory	22204-53-1	GB 1291386	Syntex	1972	1988	NA	63	
Prothiaden	Dosulepin**	Anti-depressant	113-53-1	GB 1013574	Spofa	1965	1978	NA	43	
Prozac	Fluoxetine	Anti-depressant	54910-89-3	GB1493961	Lilly and Co	1977	1995	2000	43	
Serevent	Salmeterol	Asthma	89365-50-4	GB2176476	Glaxo	1987	2004	NA	16	
Seroxat	Paroxetine	Anti-depressant	61869-08-7	GB1422263	Ferrosan	1976	1994	1999	30448	MPA Services, Patent Archives
Tagamet	Cimetidine	Acid reflux	51481-61-9	GB1338169	SmithKline & French	1971	1992	NA	41033	Espacenet, Patent Archives, Derwent Index, MPA Services
Tenormin	Atenolol	Hypertension	29122-68-7	GB 1285038	ICI	1972	1990	NA	54297	MPA Services, Espacenet, Patent Archives
Tritace	Ramipril	Hypertension	87333-19-5	EP79022	Hoechst AG	1983	2002	2004	27898	USPTO, Espacenet, MPA services
Zantac	Ranitidine	Peptic Ulcer Disease	66357-35-5	GB 1565966	Allen & Hanburys	1980	1997	NA	46673	MPA Services, Espacenet, Patent Archives
Zestril	Lisinopril	Angiotensin Converting Enzyme (ACE)	83915-83-7	EP12401	Merck & Co	1980	1999	2002	30642	Merck Index, Espacenet, MPA Services
Zocor	Simvastatin	Controls Hyperlipidemia	79902-63-9	EP33538	Merck and Co	1981	2001	NA	34216	Espacenet, MPA services
Zoton	Lansoprazole	Proton Pump Inhibitor	103577-45-3	EP174726	Nippon Chemipar	1986	2001 (non-payment of fees)	NA	37264	USPTO, Espacenet



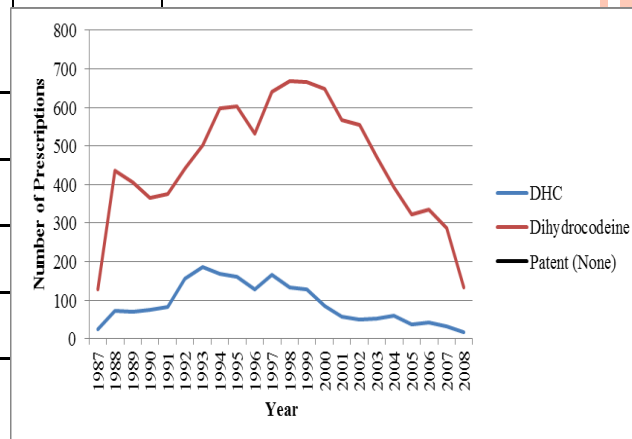
# HIGH BRANDED LOW GENERIC

Branded Drug	Generic Drug	Therapeutic Class	CAS Number	Patent Number	Patentee	Year of Patent Granted	Year of Patent Expiration	Supplementary Protection Certificate (SPC)	Total Number of Prescriptions (Rx) between 1987 and 2008	Sources
Adalat	Nifedipine	Hypertension	21829-25-4	GB1173862	Farbenfabriken Bayer AG	1969	1988	NA	26905	
Becotide	Beclomethasone	Asthma	08/09/5334	GB912378	Merck and co	1962	1982	NA	43184	
Feldene	Piroxicam	Anti-inflammatory	36322-90-4	GB1257180	Pfizer	1971	1989	NA	30313	
Frumil	Furosemide/ Amiloride HCL (co-amilofruse)	Water Retention	54-31-9	GB936417 (fru)	Hoechst AG	1963	1983	NA	13889	
			2016-88-8	GB1066855 (am)	Merck and co	1967	1987			
GNT	Glyceryl trinitrate	Angina	55-63-0	NA	NA	Pre 1900	NA	NA	23520	
Maalox	Aluminium hydroxide	Acid Reflux	21645-51-2	NA	NA	NA	NA	NA	17916	
Maxolon	Metoclopramide	Anti-emitic/ gastroprokinetic (Nausea/Vomiting)	364-62-5	GB 994023	Ile de France	1965	1978	NA	13126	Patent Archives, Espacenet
Oruvail	Ketoprofen	Anti-inflammatory	22071-15-4	GB1164585	Rhone Poulenc SA	1969	1989	NA	13963	Patent Archives, Espacenet
Prempak	Oestrogens + Progesterone (Norgestrel)	Hormone Replacement Therapy	82115-62-6	US2565115	Squibb & Son	1951	Expired	NA	51598	Merck Index, Espacenet
			57-83-0	US2379832	Schering Corp	1945	Expired	NA		
Ponstan	Mefenamic acid	Anti-inflammatory	67861-88-7	GB989951	Parke Davis and Co	1965	1985	NA	17017	Espacenet, Patent Archives
Traxam	Felbinac	Anti-inflammatory	5728-52-9	FR798941	IG Farbenindustrie AG	1936	Expired	NA	14881	Merck Index, Espacenet
Tryptizol	Amitriptyline	Anti-depressant	50-48-6	GB858187	Hoffman and La	1961	Expired	NA	24354	Patent Archives, Espacenet
Ventolin	Salbutamol	Asthma	18559-94-9	GB1200886	Allen & Hanbury's	1970	1987	NA	54961	Espacenet, Merck Index



# HIGH GENERIC LOW BRANDED

Branded Drug	Generic Drug	Therapeutic Class	CAS Number	Patent Number	Patentee	Year of Patent Granted	Year of Patent Expiration	Supplementary Protection Certificate (SPC)	Total Number of Prescriptions (Rx) between 1987 and 2008
Aprinox	Bendroflumethiazide	Hypertension	78-48-3	GB 863474	F. Lund and W. O. Godtfresen	1961	Expired	NA	42441
Brufen	Ibuprofen	Anti-inflammatory	15687-27-1	GB971700	Boots Pure Drug Co	1961	Expired	NA	203300
Deltastab	Prednisolone	Anti-inflammatory	50-24-8	US2837464	Schering Corp	1958	Expired	NA	29144
DHC	Dihydrocodeine	Severe Pain Relief	125-28-0	NA	NA	Introduced 1911	NA	NA	13592
Flexin	Indocid	Analgesic/Anti-inflammatory	53-86-1	GB 997638	Merck and Co	1965	1978	NA	21409
Inderal	Propranolol	Hypertension	525-66-6	GB 994918	ICI	1965	1979	NA	11778
Lasix	Furosemide	Loop Diuretic – water retention	54-31-9	GB936417	Hoechst AG	1963	1983	NA	22037
Panadol	Paracetamol	Analgesic	103-90-2	US2998450	Warner Lambert	1961	Expired	NA	24722
Zydol	Tramadol	Analgesic	27203-92-5	GB997399	Chem Gruenthal GMBH	1964	1984	NA	14306



# MODELS USED IN THE CURRENT RESEARCH

- Naïve Model
- Moving Average Model
- Single Exponential Smoothing (SES)
- Repeat Purchase Diffusion Model (RPDM)
- Bass Diffusion Model



# RESULTS – BRANDED THEN GENERIC

Branded	Benchmark	EWMA		Diffusion	
		Exponential Smoothing	Moving Average	Bass	RPDM
	Naïve				
ME(Bias)	-83.11	-134.94	-127.28	-334.33	-327.50
RAE(Accuracy)	1.00	1.53	1.58	4.21	4.40
MSE(Uncertainty)	261458.16	371854.37	419259.71	1092619.18	1237103.57

Generic	Benchmark	EWMA		Diffusion	
		Exponential Smoothing	Moving Average	Bass	RPDM
	Naïve				
ME(Bias)	-82.12	-134.75	-87.81	-56.58	-5.21
RAE(Accuracy)	1.00	1.48	1.51	3.49	3.73
MSE(Uncertainty)	198214.64	341448.32	404526.49	1347374.97	1663575.54

Drug	RPDM	Bass
Lustral	0.78	0.78
Ranitidine	0.93	0.89
Zantac	0.88	0.80
Cimetidine	0.99	0.92
Tagamet	0.85	0.74
Atenolol	0.98	0.67
Tenormin	0.80	0.73
Mobic	0.72	0.73
Naproxen	0.75	0.75
Naprosyn	0.98	0.74
Tritace	0.70	0.71
Zocor	0.64	0.66
Serevent	0.58	0.38
Seroxat	0.75	0.76
Losec	0.44	0.54
Diclofenac	0.98	0.91
Defenac	0.91	0.82
Dosulepin	0.74	0.76
Prothiaden	0.97	0.77
Cardura	0.60	0.59
Enalapril	0.86	0.90
Innovace	0.73	0.72
Prozac	0.76	0.78
Zoton	0.68	0.62
Zestril	0.67	0.70
Lofepramine	0.82	0.84
Gamanil	0.95	0.79



# RESULTS – HIGH BRANDED LOW GENERIC

Branded	Benchmark	EWMA		Diffusion	
	Naïve	Exponential Smoothing	Moving Average	Bass	RPDM
ME(Bias)	-58.47	-123.74	-122.43	-365.81	-309.11
RAE(Accuracy)	1.00	1.85	1.78	4.81	4.80
MSE(Uncertainty)	155842.58	229410.24	357958.64	599272.17	703422.40

Generic	Benchmark	EWMA		Diffusion	
	Naïve	Exponential Smoothing	Moving Average	Bass	RPDM
ME(Bias)	-7.48	-9.38	-10.15	-17.05	-2.23
RAE(Accuracy)	1.00	1.21	1.40	2.40	2.61
MSE(Uncertainty)	6350.14	7285.49	13739.63	17616.17	21974.55

Drug	RPDM	Bass
Aluminium Hydroxide	0.80	0.49
Maalox	0.94	0.74
Becló	0.74	0.70
Becotide	0.26	0.32
Co-amilofruse	0.81	0.77
Frumil	0.92	0.81
Felbinac	0.57	0.59
Traxam	0.92	0.78
Glyceryl Trinitrate	0.26	0.28
GNT	0.97	0.69
Ketoprofen	0.47	0.15
Oruvaíl	0.88	0.73
Mefenamic Acid	0.82	0.81
Ponstan	0.95	0.73
Metoclopramide	0.37	0.40
Maxolon	0.84	0.45
Nifedipine	0.87	0.89
Adalat	0.89	0.48
Oest/Progesterone	0.70	0.66
Prempak	0.81	0.83
Piroxicam	0.78	0.79
Feldene	0.93	0.73
Salbutamol	0.59	0.60
Ventolin	0.48	0.32
Amitriptyline	0.80	0.49
Tryptizol	0.97	0.74





# RESULTS – HIGH GENERIC LOW BRANDED

Branded	Benchmark	EWMA		Diffusion	
		Exponential Smoothing	Moving Average	Bass	RPDM
	Naïve				
ME(Bias)	-36.79	-102.30	-79.08	-292.06	-276.98
RAE(Accuracy)	1.00	2.15	1.73	5.35	5.59
MSE(Uncertainty)	21199.25	108823.30	46540.67	348546.20	353349.73

Generic	Benchmark	EWMA		Diffusion	
		Exponential Smoothing	Moving Average	Bass	RPDM
	Naïve				
ME(Bias)	-50.81	-51.68	-68.75	-26.79	105.53
RAE(Accuracy)	1.00	1.23	1.53	2.59	2.86
MSE(Uncertainty)	190881.37	206286.76	509913.82	1300270.10	1700203.04

Drug	RPDM	Bass
Indocid	0.93	0.72
Flexin	0.98	0.59
Bendroflumethiazide	0.82	0.84
Aprinox	0.89	0.62
Dihydrocodeine	0.78	0.60
DHC	0.49	0.72
Furosemide	0.95	0.83
Lasix	0.91	0.48
Ibuprofen	0.86	0.85
Brufen	0.95	0.68
Paracetamol	0.68	0.75
Panadol	0.85	0.86
Prednisolone	0.22	0.28
Deltastab	0.72	0.73
Propranolol	0.26	0.34
Inderal	0.88	0.52
Tramadol	0.94	0.95
Zydol	0.34	0.41



# DISCUSSION – BRANDED THEN GENERIC

Branded	Benchmark	Drift									
		Naïve+10% drift	Naïve+20 %drift	Naïve+30% drift	Naïve+40% drift	Naïve+50% drift	Naïve+60% drift	Naïve+70 %drift	Naïve+80 %drift	Naïve+90 %drift	Naïve+100 %drift
ME(Bias)	-83.11	-76.01	-68.93	-61.81	-54.71	-47.61	-40.48	-33.42	-26.32	-19.22	-12.12
RAE(Accuracy)	1.00	0.98	0.98	1.00	1.02	1.06	1.09	1.14	1.19	1.24	1.32
MSE(Uncertainty)	261458.16	257314.60	258543.24	265144.09	277117.15	294462.41	317180.53	345269.56	378731.44	417565.53	461771.83

Generic	Benchmark	Drift									
		Naïve+10% drift	Naïve+20 %drift	Naïve+30% drift	Naïve+40% drift	Naïve+50% drift	Naïve+60% drift	Naïve+70 %drift	Naïve+80 %drift	Naïve+90 %drift	Naïve+100 %drift
ME(Bias)	-82.12	-77.98	-73.84	-69.71	-65.57	-61.43	-56.56	-53.15	-49.01	-44.87	-40.73
RAE(Accuracy)	1.00	0.95	0.90	0.86	0.82	0.79	0.79	0.79	0.81	0.85	0.91
MSE(Uncertainty)	198214.64	185541.65	175497.55	168082.35	163296.04	161138.62	161684.64	164710.47	170439.73	178797.89	189784.94



# DISCUSSION – HIGH GENERIC LOW BRANDED

Branded	Benchmark	Drift									
		Naïve+10% drift	Naïve+20% drift	Naïve+30% drift	Naïve+40% drift	Naïve+50% drift	Naïve+60% drift	Naïve+70% drift	Naïve+80% drift	Naïve+90% drift	Naïve+100% drift
	Naïve										
ME(Bias)	-58.47	-51.89	-45.30	-38.71	-32.13	-25.54	-18.96	-12.37	-5.78	0.80	7.39
RAE(Accuracy)	1.00	0.95	0.90	0.87	0.84	0.83	0.84	0.87	0.92	0.97	1.04
MSE(Uncertainty)	155842.58	144656.62	137092.54	133150.34	132830.03	136131.59	143055.05	153600.38	167767.60	185556.70	206967.68

Generic	Benchmark	Drift									
		Naïve+10% drift	Naïve+20% drift	Naïve+30% drift	Naïve+40% drift	Naïve+50% drift	Naïve+60% drift	Naïve+70% drift	Naïve+80% drift	Naïve+90% drift	Naïve+100% drift
	Naïve										
ME(Bias)	-7.48	-7.14	-6.79	-6.44	-6.10	-5.75	-5.41	-5.06	-4.71	-4.37	-4.02
RAE(Accuracy)	1.00	0.99	1.00	1.03	1.07	1.11	1.17	1.22	1.28	1.35	1.41
MSE(Uncertainty)	6350.14	5954.06	5677.42	5520.23	5482.48	5564.18	5765.32	6085.90	6525.93	7085.40	7764.31



# DISCUSSION – HIGH BRANDED LOW GENERIC

Branded	Benchmark	Drift									
		Naïve+10 %drift	Naïve+20 %drift	Naïve+30 %drift	Naïve+40 %drift	Naïve+50% drift	Naïve+60 %drift	Naïve+70 %drift	Naïve+80 %drift	Naïve+90 %drift	Naïve+100 %drift
ME(Bias)	-36.79	-32.56	-28.34	-24.12	-19.89	-15.67	-11.44	-7.22	-3.00	1.23	5.45
RAE(Accuracy)	1	0.95	0.91	0.88	0.87	0.87	0.88	0.91	0.97	1.04	1.12
MSE(Uncertainty)	21199.25	20991.79	21313.64	22164.81	23545.29	25455.08	27894.19	30862.61	34360.34	38387.39	42943.75

Generic	Benchmark	Drift									
		Naïve+10 %drift	Naïve+20 %drift	Naïve+30 %drift	Naïve+40 %drift	Naïve+50% drift	Naïve+60 %drift	Naïve+70 %drift	Naïve+80 %drift	Naïve+90 %drift	Naïve+100 %drift
ME(Bias)	-50.81	-48.77	-46.73	-44.68	-42.64	-40.60	-38.56	-36.52	-34.48	-32.44	-30.40
RAE(Accuracy)	1.00	0.97	0.95	0.95	0.95	0.96	0.98	1.01	1.04	1.07	1.12
MSE(Uncertainty)	190881.37	173568.10	159902.37	149884.20	143513.58	140790.50	141714.98	146287.01	154506.59	166373.72	181888.40



# CONCLUSIONS

- GP's within the UK have a tendency to prescribe branded and generic drugs differently
- Simpler models forecast pharmaceutical life cycles with a greater level of accuracy than more complex ones.
- Most accurate of the current research = Naïve+%drift
- Aaker and Jacobson (1987) found that when modelling market share using the naive market share model, its predictive power was relatively high.
- Brodie & de Kluyver (1987) found that a number of econometric market share models perform no better than a 'naive' model.

# CONCLUSIONS

- This research provides a basis for the NHS in employing any cost saving techniques when looking at how different pharmaceuticals are prescribed, and forecasting how they may be prescribed in the future
- As for pharmaceutical companies this research will allow them to discover, when it is best in the life cycle of the branded pharmaceutical to introduce strategies to prolong its life cycle and slow down the number of generic prescriptions written



**THANK YOU**

*Any Questions?*