A Structural Analysis of Detailing, Publicity and Correlated Learning: The Case of Statins

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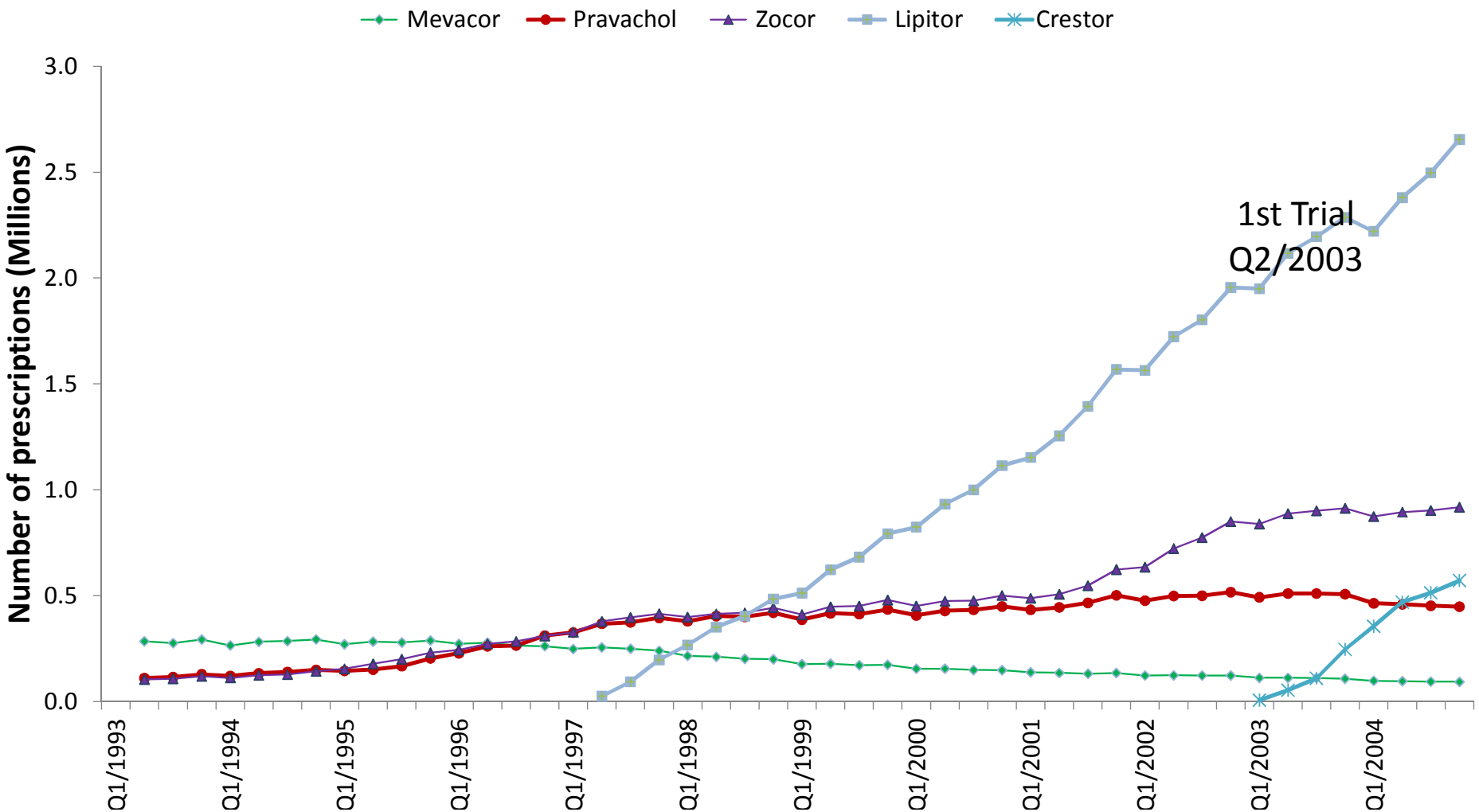
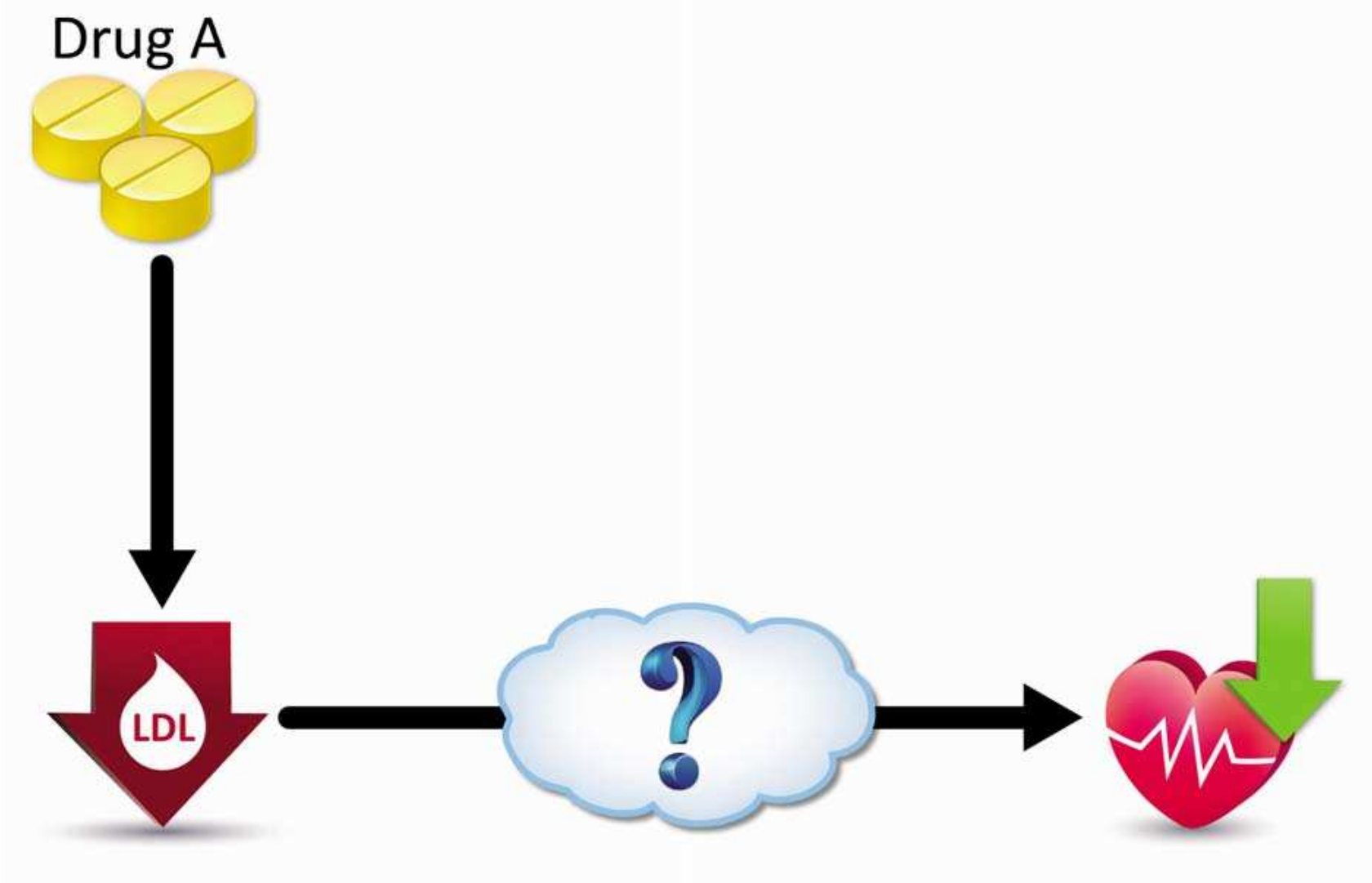
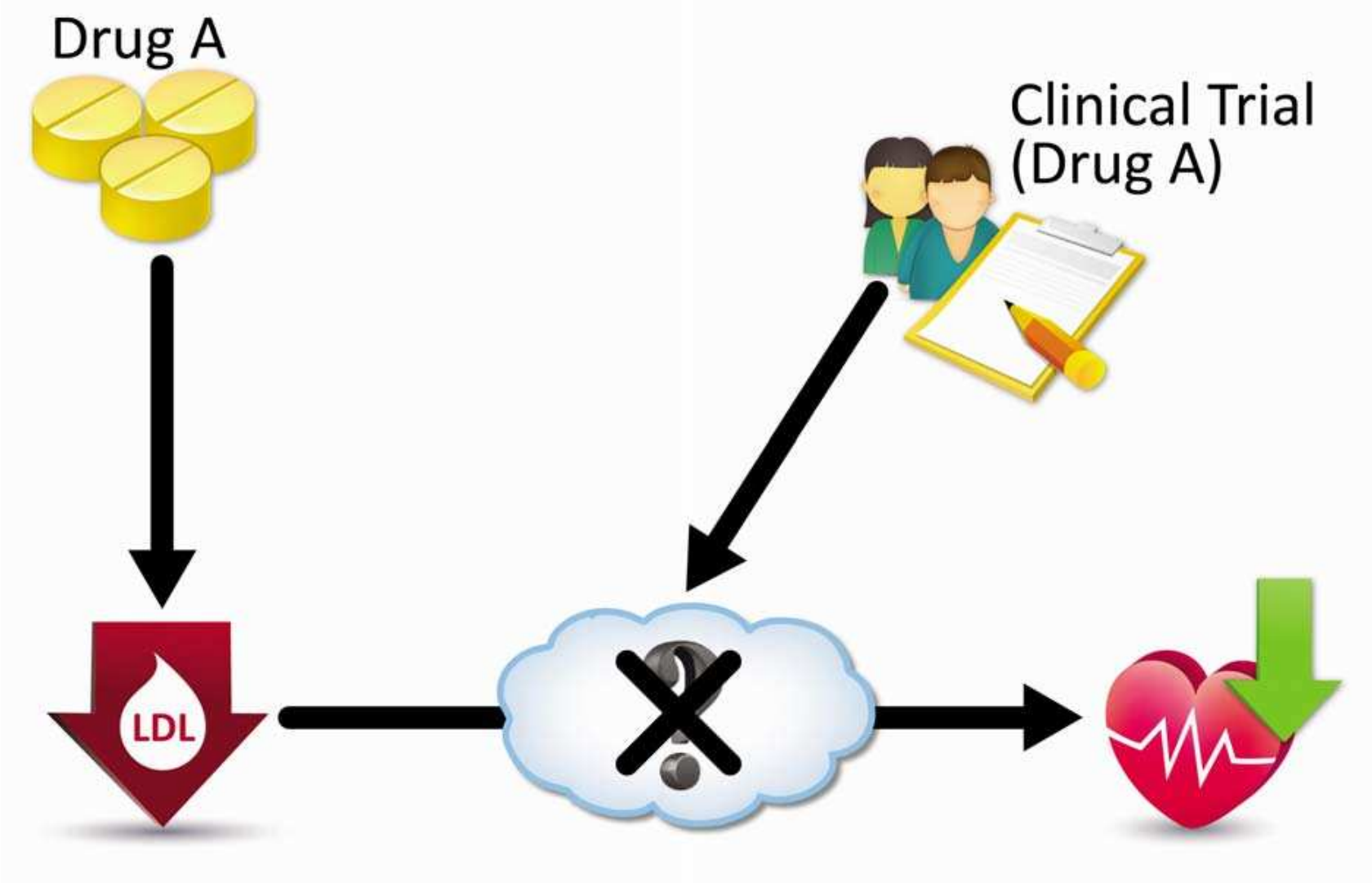
Motivation

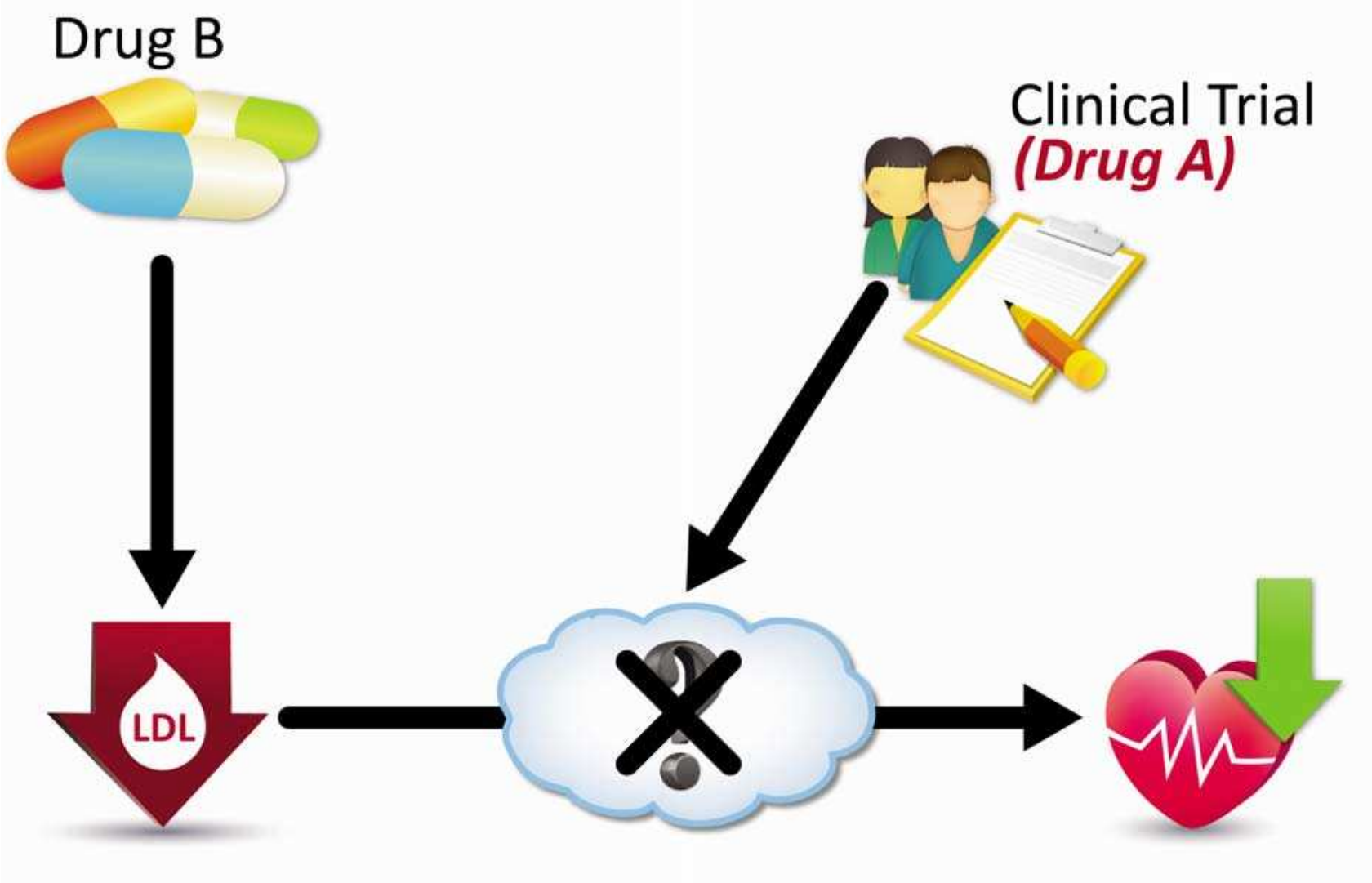

Mevacor
Pravachol
Zocor
Lipitor
Crestor
Number of prescriptions (Millions)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1st Trial
Q2/2003
Q1/1993
Q1/1994
Q1/1995
Q1/1996
Q1/1997
Q1/1998
Q1/1999
Q1/2000
Q1/2001
Q1/2002
Q1/2003
Q1/2004


Drug A
LDL
?

Correlated Learning



Correlated Learning



Research Objectives

- Develop a demand model with correlated learning across brands within a category
- Quantify the extent of correlated learning using data on market shares and quality signals (landmark clinical trials)
  - Quantify the late mover advantages
- Taking the presence of switching costs into consideration by employing switching rate data

Sales and Detailing Data

- Quarterly Canadian data for each statin between Q2 1993 and Q4 2004 from IMS Canada
  - Prescription volume, Detailing
- Quarterly data on switching between Q2 1993 and Q4 2004 from Ontario Health Insurance Program (OHIP)
  - % of statin users who switch from a given statin to another statin (2.10% on average) $\rightarrow$ Switching costs exist.

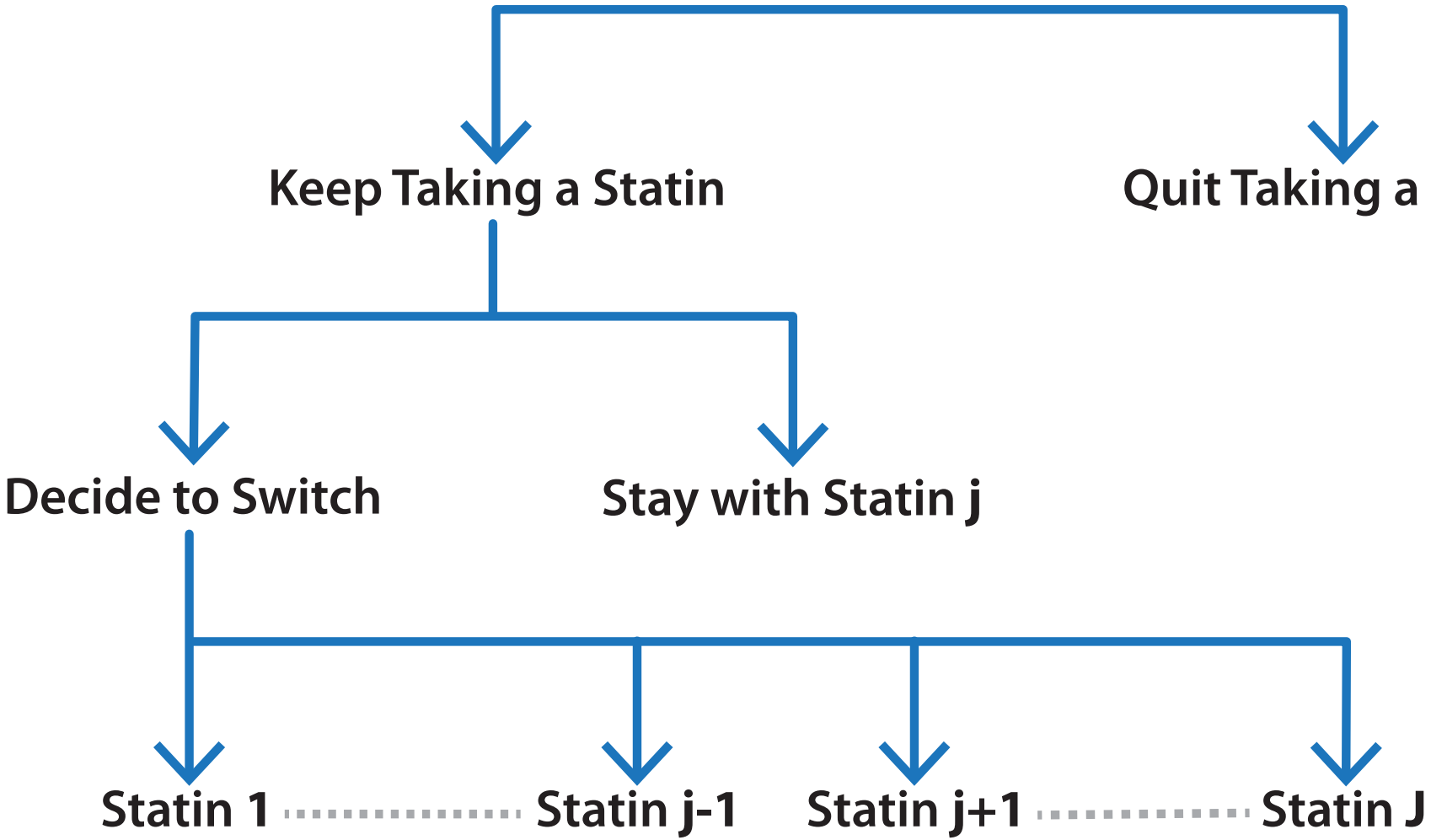
Landmark Clinical Trials

- It is very difficult for physicians to learn about drugs' efficacy in heart disease risks from patient's feedback.
- Collect 12 landmark clinical trials reporting the efficacy of statins in reducing heart disease risks between 1993 and 2004.
- The number of patients consists of 2,000 to 10,000 and the follow-up period ranges from 2 to 6 years.
- They provide observable signals (to researchers) on how efficient a statin is in reducing heart disease risks.

Publicity Data

- 2,754 articles mentioning "statin" from "Canadian Accessible Sources" in Factiva between year 1986 and 2004
- Classify articles along three dimensions
  1. Lowering cholesterol levels (short-term efficacy)
  2. Reducing heart disease risks (long-term efficacy)
  3. Side effects
- Try to overcome the ambiguity of single dimensional coding scheme
- Details are provided in Ching, Clark, Horstmann and Lim (2012)

Decision Process of Existing Patient



Efficacies of Statins

- q_j^c denotes the true efficacy in lowering cholesterol levels of drug j
  - The efficacy in lowering cholesterol levels is known to physicians
  - A meta-analysis provides such information
- q_j^h denotes the true efficacy in reducing heart disease risks of drug j
  - The efficacy in reducing heart disease is uncertain to physicians
  - Physicians learn about this efficacy from landmark clinical trials

Let q_j^h be the true efficacy in reducing heart disease risks of drug j

$$q_j^h = q_j^c \cdot \beta_j,$$

where q_j^c is the efficacy in lowering cholesterol levels and β_j is the "efficiency ratio".

Initial Prior Beliefs

Initial prior beliefs on "efficiency ratio" are constructed as follows (before any landmark trials are available)

$$\begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix}_{t=0} \sim N\left(\begin{pmatrix} \underline{\beta} \\ \underline{\beta} \end{pmatrix}, \sigma_\beta^2 \begin{pmatrix} 1 & \rho_0 \\ \rho_0 & 1 \end{pmatrix} \right),$$

where $\underline{\beta}$ is the mean initial prior belief about the efficiency ratio of each statin.

Quality Signal

Let β_j be the true mean level of the efficiency ratio for drug j. A noisy but unbiased observable signal from clinical trial l for drug j is

$$\tilde{\beta}_{jl} = \beta_j + \zeta_l$$

where $\zeta_l \sim N(0, \sigma_\zeta^2/N_l)$ and N_l denotes the number of patients who participate in landmark clinical trial l.

Updating Process for Drug 2

Assume that a physician learns about clinical trial l for drug 1 at time t.

Her posterior belief on the efficiency ratio of drug 2 is

$$\beta_{2t+1} = \beta_{2t} + \frac{\pi_t}{\sigma^2_{\beta 2t} + \sigma^2_{\zeta 1l}}(\tilde{\beta}_{1l} - \beta_{1t})$$

where π_t is the covariance in prior beliefs about "efficiency ratio" of drug 1 and 2 at time t.

Her posterior variance on the efficiency ratio of drug 2 is

$$\sigma^2_{\beta 2t+1} = \sigma^2_{\beta 2t} - \frac{\pi_t^2}{\sigma^2_{\beta 2t} + \sigma^2_{\zeta 1l}}$$

- The probability that a physician will learn the most updated clinical information about drug j at time t is

$$P_{info}(detail_{jt}, PUB_{jt}) = \frac{exp(\alpha_0 + \alpha_d \cdot detail_{jt} + \alpha_p \cdot PUB_{jt})}{1 + exp(\alpha_0 + \alpha_d \cdot detail_{jt} + \alpha_p \cdot PUB_{jt})}$$

where $detail_{jt}$ is detailing spending for drug j at time t; PUB_{jt} denotes a vector of three dimensional (lc, rh and se) brand specific publicity variables for drug j at time t.

Types of Physicians

- If there are n_t clinical trials up to time t, theoretically there will be 2^{n_t} types of physicians at time t. $(n_t = \sum_{j=1}^{J} n_{jt})$
- To simplify the model, I assume that if a physician learns about a clinical trial for drug j at time t, she will learn about all the published clinical trials for drug j prior to time t.
- Then, the number of physician types reduces to $(n_{1t} + 1) \cdot (n_{2t} + 1) \cdots (n_{Jt} + 1)$ under this assumption where n_{jt} denotes the number of clinical trials for drug j up to time t.

Utility Function

Let patient i's utility of consuming statin j at time t be

$$U_{ijt} = \omega \cdot q_j^h + b_j + \epsilon_{ijt},$$

where q_j^h denotes drug j's efficacy in reducing heart disease risks; b_j captures time-invariant brand specific preference.

Physician k's expected utility of prescribing drug j to patient i at time t becomes

$$E[U_{ijt}^k | I^k(t)] = \omega \cdot E[q_j^h | I^k(t)] + \kappa_d \cdot STK\_detail_{jt} + b_j + \epsilon_{ijt},$$

where STK_detail_{jt} is a persuasive detailing goodwill stock for drug j at time t.

Estimation

- The total demand for drug j at time t is expressed as follows.

$$d_{jt} = \hat{d}^1_{jt} + \hat{d}^2_{jt} + \hat{d}^3_{jt} + e_{jt}$$

where $\hat{d}^1_{jt}$, $\hat{d}^2_{jt}$, $\hat{d}^3_{jt}$ are estimated demand for drug j at time t from "new patients", "switchers" and "retainers",respectively; e_{jt} is a measurement error.

- Estimate the model using Maximum Likelihood.

Identification

- Correlated Learning
  - Sales changes after a clinical trial is released identify correlated learning parameters.
- Informative Detailing
  - Variations in sales and detailing before and after each clinical trial release identify the informative effects.

Result Tables(1)

	Estimates	S.E.
Learning Parameters		
$\underline{\beta}$ (Initial Prior Belief on Efficiency Raito)	0.1132	0.0596
σ_β^2 (Initial Prior Variance on Efficiency Raito)	1.0000	
σ_ζ^2 (Signal Variance from 1,000 Patients)	**6.0353**	0.9996
ρ_0 (Correlation Term in Initial Prior)	**0.6578**	0.2634
Statin Choice Stage, Utility Parameters		
α_0 (Constant)	**-8.0521**	0.9993
α_d (Informative Detailing)	**3.4070**	1.0096
α_{lc} (Brand Specific Publicity in Lowering Cholesterol Levels)	0.3661	0.2702
α_{rh} (Brand Specific Publicity in Reducing Heart Disease Risks)	**0.3514**	1.0335
α_{se} (Brand Specific Publicity in Side Effects)	-0.0184	1.0018
ω (Coefficient of Perceived Quality)	1.1112	0.6330
κ_d (Persuasive Detailing)	**0.0120**	0.0042
Brand Dummies		
Pravachol	**0.8696**	0.3887
Zocor	**0.9702**	0.3859
Lipitor	**1.0990**	0.5409
Crestor	0.2380	0.7339
Log Likelihood	-2064.56	

Estimates shown in bold are significant at 5% level.

Results Tables(2)

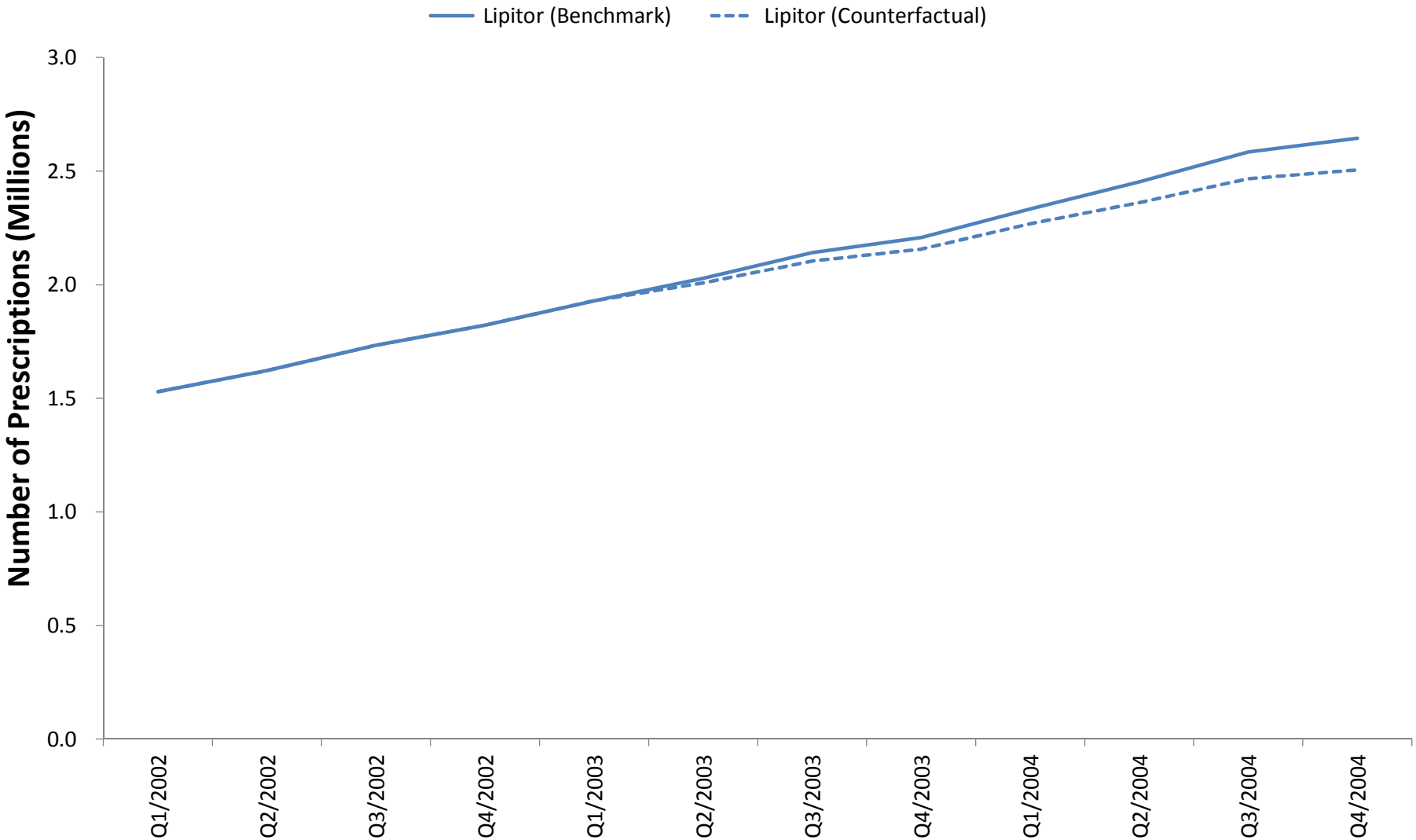
	Estimates	S.E.
Adoption Decision Stage Parameters		
α^s_0 (Market Expansion Stage Constant)	**-5.2073**	0.2441
α^s_c (Clinical Trial * Aggregate Detailing Stock)	0.0111	0.0085
α^s_d (Aggregate Detailing Stock)	**0.0082**	0.0011
α^s_{lc} (General Publicity Stock in Lowering Cholesterol Levels)	0.3661	0.2702
α^s_{rh} (General Publicity Stock in Reducing Heart Disease Risks)	0.3514	1.0335
α^s_{se} (General Publicity Stock in Side Effects)	-0.0184	1.0018
Additional Parameters		
δ^s_d (Carryover Rate of Detailing in Adoption Decision)	**0.9720**	0.0060
δ^s_p (Carryover Rate of Publicity in Adoption Decision)	**0.7375**	0.0432
δ_i (Carryover Rate of Information in Statin Choice)	**0.7028**	0.2102
δ_p (Carryover Rate of Persuasive Detailing in Statin Choice)	**0.8878**	0.0466
Standard Deviation of e_{jt} (in Hundred Thousand)	**0.3213**	0.0207
Log Likelihood	-2064.56	

Estimates shown in bold are significant at 5% level.

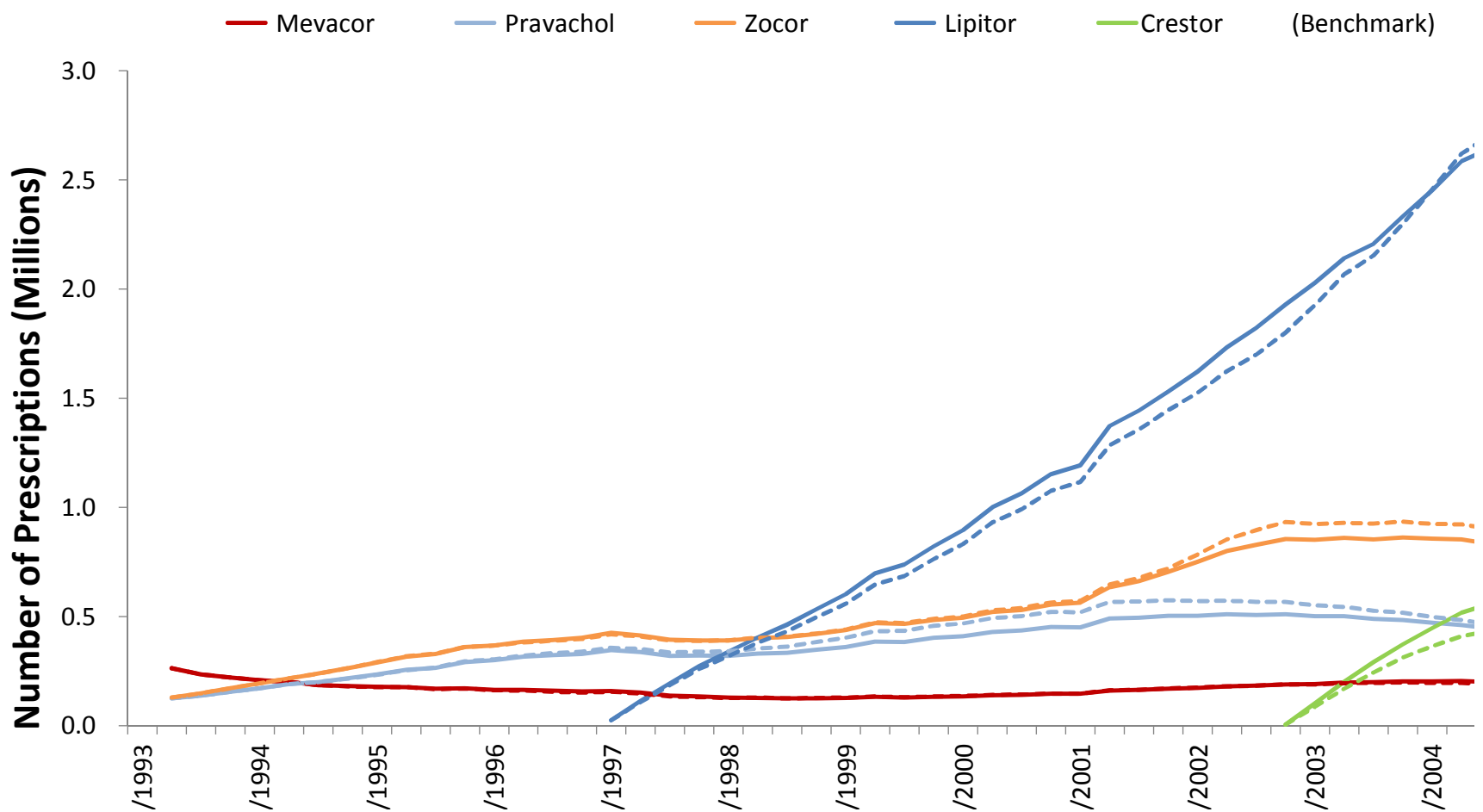
Results

- The estimate of the correlated learning parameter (ρ_0) is 0.658, which suggests a partial information spill-over.
- The estimates of both persuasive (κ_d) and informative (α_d) detailing parameters are positive and significant.
- The information carryover rate of physicians (δ_p) is 0.89 per quarter.
- Publicity in reducing heart disease risks (α_{rh}) has a significant impact on updating physicians about clinical trial information.
- Only aggregate detailing stock (α_d^s) matters in adoption stage.

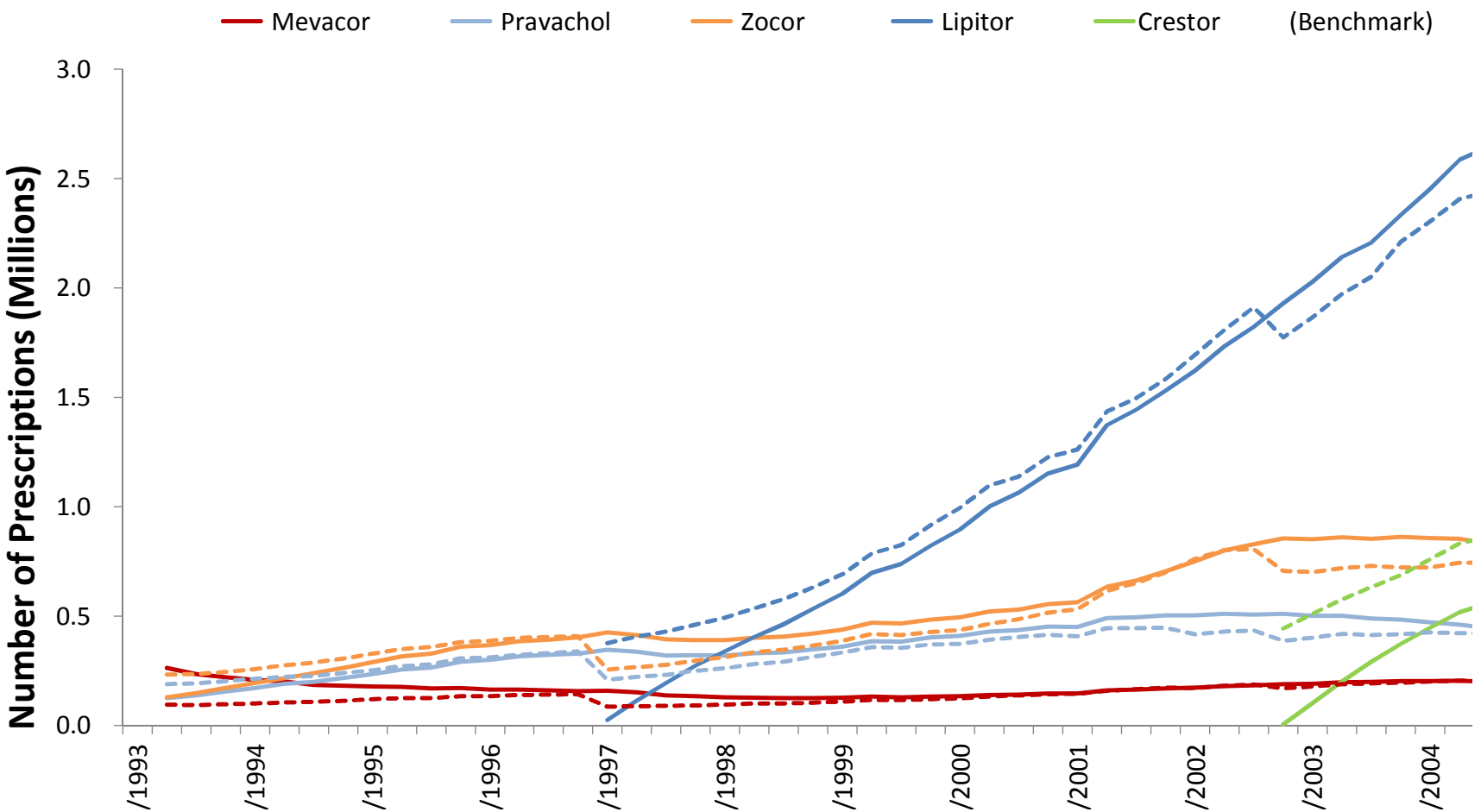
Expt 1: No Landmark Trials for Lipitor



Expt 2: No Correlated Learning



Expt 3: No Switching Cost



Conclusion

- Our results suggest that late mover advantages can be generated by correlated learning.
- Although Lipitor can free-ride on incumbents' clinical trials, its own clinal trial is still significant for demand.
- This model can be extend to other market where products qualities are uncertain, e.g., Ipad vs Android tablet.