Regulation, Generic Competition and Pharmaceutical Prices

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1 Introduction

- When patent expires, competitors may enter with generics.
- Since generics have same therapeutic effect, we expect that
  - only relative prices matters for choice of drug,
  - and that fierce price competition take place.
- This is not what is happening! A robust empirical regularity is that
  - the original drug (brand-name) is priced higher than generics,
  - and still obtains positive market shares.

- Given that patent protection is sufficient for firms to recoup R&D costs,
  - the efficient outcome in the post-patent period should be $p = mc$.
- Thus, large market shares of high-priced brand-names are unsatisfactory from a policy perspective.
- As a response, most countries impose regulation to drive down prices and expenditures.
- However, Danzon and Chao (2000) argue that regulation drives out competition and is counterproductive.
  - Countries with lenient regulation have stronger (generic) competition.

- We analyse the impact of regulation on generic competition and prices.
  - Theoretical: Branded-generic competition PC and RP regulation.
  - Empirical: Policy experiment in Norway in 2003 on a sample of off-patent drugs.
    * Treatment group: Drugs shifting from PC to RP,
    * Comparison group: Drugs subject to PC for whole period.
- Detailed product-level panel dataset for the period 2001-2004.
  - Variation over time (before and after the reform),
  - Across products subject to different regulations (PC and RP)

- Related literature on RP
  - Danzon and Liu (1998); Danzon and Ketcham (2004): Price convergence hypothesis
    - Brand-names (generics) reduce (increase) price towards RP.
  - Aronsson et al (2001) find weak effects of the Swedish RP system on brand-name market shares (5 out of 12 substances).
  - Pavcnik (2002) finds strong price effects of the German (therapeutic) RP, especially on brand-names.
  - Brekke et al. (2007) find a negative cross-price effects on non-referenced therapeutic competitors.

2 A Theoretical Model

- Consider a therapeutic market with two firms
  - Firm B (firm G) offers brand-name (generic) brand-name drug.

- Consumer utility from drug i

$$U_i = \begin{cases} \theta\tau - c_b & \text{if } i = b \\ \tau - c_g & \text{if } i = g \end{cases},$$

  - τ is consumer heterogenity uniformly distributed on $[0, t]$
  - $\theta > 1$ is (perceived) quality difference (marketing)
  - c_i is the patient co-payment for drug i

- Consumer indifferent between brand-name and generic drug

$$\theta\widehat{\tau} - c_b = \widehat{\tau} - c_g \quad \Leftrightarrow \quad \widehat{\tau} = \frac{c_b - c_g}{\theta - 1}.$$

- Demand for brand-name and generic

$$D_b = \frac{M}{t}\left(t - \widehat{\tau}\right) \quad \text{and } D_g = \frac{M}{t}\left(\widehat{\tau} - c_g\right),$$

- Firm profits

$$\pi_i = \left(p_i - c\right) D_i,$$

- Bertrand game: Firms set prices simultaneously and independently.

2.1 No regulation

- Patient co-payment: $c_i = f + \alpha p_i$,
  - $f > 0$ is a fixed fee; $\alpha \in (0, 1)$ is the coinsurance rate.

- Best-response functions (strategic complements)

$$p_b^r(p_g) = \frac{1}{2}\left(p_g + \frac{t(\theta - 1)}{\alpha}\right),$$

$$p_g^r(p_b) = \frac{1}{2\theta}\left(p_b - \frac{f(\theta - 1)}{\alpha}\right).$$

- In equilibrium, we get that $p_b^* > p_g^*$ (difference increasing in θ).

2.2 Price cap regulation

- Brand-name faces a binding price cap $\overline{p}_b$ set by regulator.

- Effects of stricter PC (lower $\overline{p}_b$)
  - Brand-name less expensive $=>$ shifting demand towards drug b.
  - Prices strategic complements $=>$ firm G responds by lowering p_g.

- Net effect on (equilibrium) generic market share

$$\frac{\partial}{\partial \overline{p}_b}\left(\frac{D_g^{pc}}{D_b^{pc}+D_g^{pc}}\right) > 0.$$

- Thus, stricter price cap regulation dampens generic competition.

2.3 Reference pricing

- Under reference pricing (RP), firms are free to set drug prices.

- Instead the regulator defines a maximum reimbursement (reference price).

- For a reference price $r \in (p_g, p_b)$, the co-payment schedule is given by

$$c_b = \alpha r + (p_b - r) + f,$$

$$c_g = \alpha p_g + f.$$

Exogenous reference price

- Assume that $r \in (p_g, p_b)$ is (perceived to be) a fixed number.

- In equilibrium, we can show that

$$\frac{\partial p_g^{rp}}{\partial r} < 0 \quad \text{and} \quad \frac{\partial p_b^{rp}}{\partial r} > 0.$$

- Thus, exogenous RP triggers price convergence (towards r).

Endogenous reference price

- Assume that $r \in (p_g, p_b)$ is a function (weighted average)

$$r = \beta p_g + (1 - \beta)\, p_b.$$

- Firms' price setting is now going to affect r and thus future D_i and π_i.

- Impact of a lower r ($\Leftrightarrow$ higher weight on generic price):

$$\frac{\partial p_b^{rp}}{\partial \beta} < 0 \quad \text{and} \quad \frac{\partial p_g^{rp}}{\partial \beta} < 0.$$

  - Generic producer's incentive is now reversed!

- Impact on relative prices:

$$\frac{\partial}{\partial \beta}\left(\frac{p_b^{rp}}{p_g^{rp}}\right) < 0.$$

  - Stronger reduction in p_b than p_g.

- Impact on generic market share:

$$\frac{\partial}{\partial \beta}\left(\frac{D_g^{rp}}{D_b^{rp} + D_g^{rp}}\right) > 0.$$

  - Increase in relative co-payments (due to RP) is not outweighted by the drop in relative drug prices.

Hypotheses for the empirical analysis

- Switching from price cap regulation to (endogenous) reference pricing
  1. leads to an increase in generic market shares, and,
  2. given that price cap regulation is not excessively strict, also
     (a) a reduction in branded and generic drug prices
     (b) and a reduction in relative drug prices.

3 Institutional Background

- All prescription drugs (reimbursable or not) are subject to price control.

- *Price cap* scheme based on external referencing introduced in 2000
  - Maximum price on each product based on *foreign prices*.
    - Norwegian basket consists of 9 Western European countries.
  - Price cap is set equal to the average of 3 lowest foreign prices.
  - Generics obtain the same PC as brand-names, but the PC almost never binds (only for brand-names).

- *Reference pricing* (index price) introduced in March 2003
  - Covered initially six substances, but was subsequently extended.
  - Selection of drugs: (i) cover wide set of diseases; (ii) high-volume drugs; and (iii) recent patent expiration.
  - Maximum reimbursement per substance defined as
    * sales-weighted average price of brand-names and generics (updated every 3 month).
  - Strong incentives for generic substitution at pharmacy level
    * Pharmacies got the full margin of selling a generic, but faced the full cost of selling a brand-name.

- Co-payment system for reimbursable prescription drugs
  - Patients pay 36% of the price upto a maximum of 400 NOK (50€) per script and 1.350 NOK (170€) annually.
  - All prescription drug expenditures above this are 100 % reimbursed.
  - Under RP, patients refusing to accept generic substitution must pay the full price difference.
  - In this case, the co-payment caps did not apply.
- The index price system replaced by a new RP variant from 2005 with the argument that cost savings were lower than expected.

4 Data and descriptive statistics

- Data (from Farmastat) contains information about sales value and volume (DDD) for each package sold in Norway, as well as
  - product name, manufacturer, launch date, brand-name or generic, package size and dosage.
- Data sample: 40 largest off-patent substances for 2001-2004.
- Since the index price drugs faced generic competition for a short period,
  - we include molecules with generic entry after January 1, 1998,
  - leaving us with 24 molecules (ATC-groups).

- Variables (t is time and i is substance)
  - Brand-name market shares

$$\gamma_{it} = \frac{D_{it}^{b}}{D_{it}^{b} + \sum_{k=1}^{n_{it}} D_{it}^{g_k}},$$

    * n_{it} = number of generics for substance i at time period t

  - Relative prices

$$\omega_{it} = \frac{p_{it}^{b}}{\sum_{k=1}^{n_{it}} \alpha_{it}^{k} p_{it}^{g_k}}, \text{ where } \alpha_{it}^{k} = \frac{D_{it}^{g_k}}{\sum_{k=1}^{n_i} D_{it}^{q_k}}.$$

  - Therapeutic competition

    * number of substances with same first 3-digits in their ATC-code.

Table 1. Sample characteristics

ATC-code	Market share	Relative price	Subject to ref. pricing	Number of generics[1]	Number of therapeutic competitors.[2]	Number of Observations
A02BC01	68.86 (14.03)	1.28 (0.09)	Yes	1	9	48
A10BA02	81.84 (4.72)	1.23 (0.13)	No	5	9	48
A10BB01	95.24 (7.81)	1.26 (0.11)	No	1	9	33
C08CA01	50.39 (15.14)	1.35 (0.15)	Yes	5	1	10
C09AA02	71.03 (21.77)	1.54 (0.16)	Yes	6	4	48
C09AA03	71.93 (21.92)	1.54 (0.14)	Yes	5	4	48
C09BA02	58.48 (10.96)	1.32 (0.05)	No	2	1	24
C10AA01	58.12 (17.92)	1.28 (0.12)	Yes	5	4	21
C10AA02	53.19 (19.63)	1.36 (0.15)	No	1	4	17
H02AB02	30.25 (5.78)	0.98 (0.09)	No	2	8	12
J01FA01	75.74 (4.19)	1.76 (0.10)	No	1	0	48
J01MA02	95.93 (8.28)	1.18 (0.12)	No	2	0	26
M01AB05	80.11 (8.00)	1.24 (0.75)	No	3	14	48
N03AF02	98.74 (1.34)	2.06 (0.49)	No	1	14	12
N05AH02	50.09 (20.10)	1.31 (0.03)	No	1	6	48
N05BA12	97.67 (1.01)	1.59 (0.10)	No	1	3	17
N05BE01	55.29 (15.69)	1.37 (0.05)	No	3	6	48
N05CF02	71.99 (13.02)	1.87 (0.21)	No	2	3	32
N06AB03	77.69 (21.37)	1.30 (0.16)	No	1	15	36
N06AB04	67.37 (29.81)	1.23 (0.16)	Yes	5	15	32
N06AB05	64.70 (25.33)	1.18 (0.07)	No	4	15	18
N06AG02	73.77 (13.12)	1.41 (0.04)	No	2	15	27
R06AE07	49.92 (18.05)	1.19 (0.12)	Yes	6	11	34
R06AX13	74.51 (18.03)	1.13 (0.08)	Yes	6	17	48

[1] Largest number of generics through the sample period.

[2] Largest numbers of therapeutic competitors through the sample period.

Table 2. Market shares, relative prices and average prices before and during the reference pricing period.

	Drugs subject to reference pricing		Drugs subject to price cap regulation	
	Before the reference pricing period	During the reference pricing period	Before the reference pricing period	During the reference pricing period
Market shares brand names	87.26 (12.13)	50.16 (13.17)	79.86 (17.86)	67.66 (21.29)
Relative prices	1.40 (0.21)	1.28 (0.21)	1.41 (0.44)	1.37 (0.25)
Average prices brand names	5.10 (3.88)	3.91 (2.78)	7.46 (6.48)	7.74 (6.41)
Average prices generics	3.92 (2.81)	3.42 (2.31)	6.39 (5.43)	6.40 (5.75)

5 Empirical method and results

- Analyse the effect of introducing RP on 3 different outcomes

  1. Relative branded-generic prices (and price effects separately)

  2. Generic competition (measured inversely by brand-name market shares)

  3. Average prices at molecule (substance) level

- Estimation strategy: comparison of 8 substances affected by RP (treatment group) with residual 16 substances (control group).

- Identification relies on (i) before-after comparison and (ii) variations in outcomes across drugs subject to different regulation.

- We estimate the following fixed effect model:

$$Y_{it} = \mathbf{X}'_{it}\boldsymbol{\beta} + a_i + \delta_t + \alpha D_{it} + \varepsilon_{it},$$

  - Y_{it} is either relative prices, brand-name market shares or average molecule prices,
  - a_i is a molecule fixed effect,
  - δ_t is a period specific effect common to all molecules,
  - ε_{it} is unobserved time-varying factors that affect outcomes,
  - $\mathbf{X}'_{it}$ contains observable variables
  - D_{it} is a dummy variable taking the value 1 if subject to RP

- Is the comparison group legitimate?
  - Is the assumption that ε_{it} is uncorrelated with D_{it} (as well as $\mathbf{X}'_{it}$ and δ_t) valid?
  - Test for pre-reform differences in price and market share trends across treatment and control group.
    - Interaction between period dummies (δ_t) and dummy variable indicating treatment status (D_i) (in the post-reform period).
  - Result: All interactions are insignificant in all three models, and F-tests show that interactions are jointly insignificant.

5.1 Relative prices

- Do RP reduce relative prices (price convergency)?
  - Yes, we find a negative, though weak, significant effect on relative prices.

- Price convergency caused by increase in generic prices?
  - Test for reform effects on prices separately

$$\ln P_{it} = \mathbf{X}'_{it}\beta + a_i + \delta_t + \alpha_1 D_{it} + \alpha_2 D_{it} * B_i + \varepsilon_{it},$$

  - No, it is caused by a larger drop in brand-name prices (36%) than generic prices (21%).

Table 4. Effects of reference pricing on relative prices and market shares. Fixed effect models with robust standard errors.

	Relative price	Market share
Relative price	-	-1.7576 (1.0690)
Products subject to reference pricing	-0.0896** (0.0238)	-13.7988** (1.6785)
Number of therapeutic competitors	-0.0396* (0.0168)	2.7148** (0.3938)
Constant	1.9194** (0.2640)	69.7341** (4.2673)
Period dummies	Yes	Yes
Molecule dummies	Yes	Yes
Number of observations	783	783
Number of ATC groups	24	24
R-squared	0.13	0.72

**: significant at the 1 percent level, *: significant at the 5 percent level.

Table 5. Effects of reference pricing on log of average brand-name and generic prices. Fixed effect models with robust standard errors.

Generics subject to reference pricing	-0.2113** (0.0196)
Brand names subject to reference pricing	-0.1479** (0.0194)
Brand names	0.2625** (0.0084)
Number of therapeutic competitors	-0.0264** (0.0056)
Number of generics	0.0073 (0.0052)
Constant	1.6956** (0.0814)
Period dummies	Yes
Molecule dummies	Yes
Number of observations	1536
Number of ATC groups	24
R-squared	0.61

**: significant at the 1 percent level, *: significant at the 5 percent level.

5.2 Generic competition

- Do RP stimulate generic competition?
  - Control for molecule and time period specific effects, relative prices, number of generic and therapeutic competitors.
  - Imply that we estimate a pure demand effect of RP (shift in market shares)

- Relative prices might be *endogenous?*
  - Use a fixed effect IV-model with relative prices in period $t-1$ as instrument.
  - Results are quite similar.

5.3 Average prices

- Quantify the effect of RP on average molecule level prices.
  - Dependent variable

$$Y_{it} = \ln \overline{p}_{it}, \text{ where } \overline{p}_{it} := \mu_{it}^{b} p_{it}^{b} + \sum_{k=1}^{n_i} \mu_{it}^{g_k} p_{it}^{g_k}.$$

  - Control for molecule and time period specific effects, the number of generic and therapeutic competitors.

Table 6. Effects of reference pricing on log of average prices. Fixed effect models with robust standard errors.

Drugs subject to reference pricing	-0.3028** (0.0236)
Number of therapeutic competitors	-0.0392** (0.0087)
Number of generics	0.0061 (0.0068)
Constant	2.1622** (0.1292)
Period dummies	Yes
Molecule dummies	Yes
Number of observations	783
Number of ATC groups	24
R-squared	0.64

**: significant at the 1 percent level, *: significant at the 5 percent level.

6 Concluding Remarks

- We have analyzed the relationship between regulation (RP and PC), generic competition and pharmaceutical prices.

- We applied a vertical differentiation model that showed that
  - Stricter PC regulation reduces generic competition, with impact on average prices being ambiguous.
  - RP stimulates generic competition, resulting in lower brand-name prices
  - The effect of RP on generic prices depends on whether RP is exogenous or endogenous.

- In the empirical part, we exploited a unique policy experiment from Norway, finding that RP leads to
  - lower brand-name and generic prices and lower relative prices,
  - fiercer generic competition (lower brand-name market shares),
  - and substantially lower average prices at molecule level.
- We conclude that RP is clearly favourable to PC regulation in the off-patent segment.
- Remarks: (i) cross-price-effects on patent-protected drugs; (ii) patient health risks due to generic substitution.

Table A.1. Effects of reference pricing on market shares. Fixed effect IV-model.

	First step	Second step
Relative price	-	0.0508 (1.9383)
Products subject to reference pricing	-0.0155 (0.0202)	-12.8326** (1.4689)
Number of therapeutic competitors	0.0006 (0.0054)	2.9695** (0.3904)
Relative price (t-1)	0.7797** (0.0208)	-
Constant	0.1198 (0.0706)	65.5888** (4.7145)
Period dummies	Yes	Yes
Molecule dummies	Yes	Yes
Number of observations	759	759
Number of molecules	24	24
R-squared	0.71	0.72

**: significant at the 1 percent level, *: significant at the 5 percent level.