

Equilibrium Market Structure and Product Variety in Successive Oligopolies

**Endogenous Market Structure and Spatial
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I. Motivation

A number of industries are characterized by:

- A small number of Upstream Firms/ Manufacturers → oligopolistic structure in the upstream sector
- Each Upstream Firm produces a range of horizontally differentiated goods
- A small number of Downstream Firms/Retailers, each selling most (or even all) of the manufacturers products → oligopolistic structure in retailing
- Intensive Product Creation Activities at the upstream sector → enhancement of product variety

I. Motivation (cont'd)

We develop a successive oligopoly model that captures some of the characteristics of the above industries in order to address the following issues:

- **The manufacturers incentives to invest in new product creation processes**
- **The manufacturers incentives to enter in the upstream market**
- **The impact of the intensity of the economies of scope on product variety offered in the market, upstream market concentration, wholesale prices and output quantities sold in the market.**
- **The welfare implications of economies of scope i.e. their impact on consumer surplus, upstream and downstream profits and total welfare**

Related Literature

- **Literature on Multi-product Firms**

Helpman (1985), Nocke and Yeaple (2006),
Anderson and de Palma (1992, 2006), ...

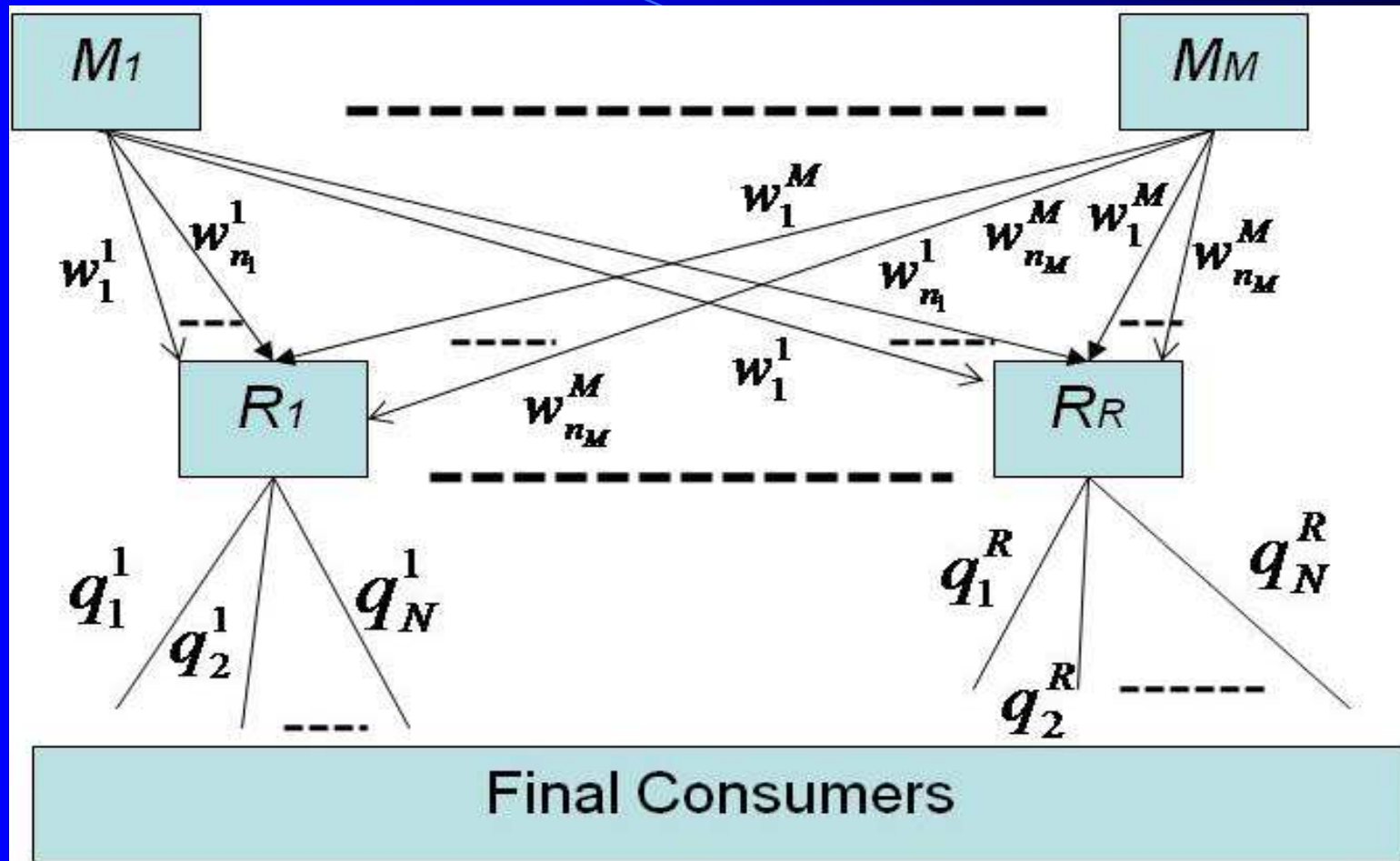
(They consider one-tier industries)

- **Literature on Vertically Related Industries**

Reisinger and Schnitzer (2008), Smith and
Thanassoulis (2008), Dobson and Waterson (2007),
...

(They consider single-product upstream firms)

Market Structure



$$N = n_1 + n_2 + \dots + n_M$$

$$(w_{1,1}, w_{1,2}, \dots, w_{1,n_1}, w_{2,1}, w_{2,2}, \dots, w_{2,n_2}, \dots, w_{M,1}, w_{M,2}, \dots, w_{M,n_M}) \equiv (w_{1,1}^1, w_{1,2}^1, \dots, w_{1,n_1}^1, w_{1,1}^2, w_{1,2}^2, \dots, w_{1,n_2}^2, w_{1,1}^M, w_{1,2}^M, \dots, w_{1,n_M}^M)$$

II. The Model (1)

Manufacturers:

- M upstream firms/manufacturers, $m=1,2,\dots,M$.
- Each manufacturer m decides how many differentiated goods to produce, n_m . The total number of goods produced is $N = n_1 + \dots + n_m$.
- Manufacturers compete in prices. Each manufacturer m sets the prices for all the good he produces. The vector of all manufacturers' prices is (w_1, \dots, w_N) , while the vector of quantities sold to the retailers is: (Q_1, \dots, Q_N)
- Each manufacturer faces the *same* cost function for the creation of a spectrum n_m of goods, $c(n_m)$, with $c(\mathbf{1}) > 0$, $c'(n_m) > 0$
- If $c''(n_m) < 0$ then there are economies of scope in the new product creation process.

II. The Model (2)

Retailers:

- R downstream firms/retailers, $r=1,2,\dots,R$, each selling all the manufacturers' goods.
- Each retailer r chooses the quantity of each good that he buys from each manufacturer and resells it to the final consumers.
- The total quantity of good i sold in the market by all retailers is Q_i , $i=1,2,\dots,N$.
- There are no reselling costs \rightarrow retailing marginal cost for each good is equal to the manufacturer's wholesale price.

II. The Model (3)

Utility function of the representative consumer:

$$U(Q_1, \dots, Q_N) = A(Q_1 + \dots + Q_N) - \frac{1}{2}(Q_1^2 + \dots + Q_N^2 + 2\gamma Q_1 Q_2 + \dots + 2\gamma Q_1 Q_N + \dots + 2\gamma Q_{N-1} Q_N) + L \quad (1)$$

- A : reflects the size of the market.
- γ : $0 < \gamma < 1$ represents the degree of product substitutability/ product differentiation .
- L : represents the income spent on the rest of the goods.

Hence, the system of the demand functions is:

$$p_i = A - Q_i - \gamma \sum_{j=1, j \neq i}^N Q_j, i, j = 1, \dots, N \quad (2)$$

II. The Model (4)

Therefore, the manufacturer m 's profit function is:

$$\pi_m^U = \sum_{i=1}^{n_m} w_i^m Q_i - c(n_m), \quad m = 1, \dots, M \quad (3)$$

where $Q_i = \sum_{r=1}^R q_i^r, \quad i = 1, \dots, N$

and the retailer r 's profit function is:

$$\pi_r^D = \sum_{n=1}^N (p_n - w_n) q_n^r, \quad r = 1, \dots, R \quad (4)$$

III. Timing of the Game

We consider a two-stage game:

- **Stage 1**: Manufacturers decide simultaneously and independently how many goods each to produce and also set simultaneously the prices of their goods.
- **Stage 2**: Retailers buy manufacturers' goods and resell them to final consumers, setting simultaneously their quantities.

The solution concept we employ is Subgame Perfect Nash Equilibrium

IV. Equilibrium Analysis

Case 1: Number of manufacturers (M) is given

In the **Symmetric SPNE** the equilibrium wholesale price and number of goods produced by each manufacturer are (implicitly) determined by the system of equations:

$$\begin{cases} w^* = \frac{A(1-\gamma)}{2(1-\gamma) + (M-1)\gamma n^*} \\ \frac{[R(A-w^*)w^*]}{(1+R)} \frac{1-\gamma + \gamma n^*(M-1)}{(1+\gamma(Mn^*-1))^2} = c'(n^*) \end{cases} \quad (5)$$

IV. Results

Let $c(n) = bn^a$, where $0 < a$ and $0 < b$. Then as a decreases economies of scope become *stronger*.

Statement: Symmetric equilibrium exists for $0 < a_L < a$.

Lemma: (i) Whenever symmetric equilibrium exists it is unique.

(ii) The equilibrium wholesale price decreases with the number of goods offered by each manufacturer n^* .

Consider the **benchmark case** where each manufacturer produces a single good incurring a cost of $c(1) = b$.

Proposition 1: When the number of manufacturers in the benchmark case is such that $N^s = M n^*$, then the equilibrium wholesale prices of the single good manufacturers are always **lower** than the prices of the multi-product manufacturers.

Proposition 2: The product variety offered by each manufacturer n^* , as well as the equilibrium profits of each manufacturer decrease in M .

V. Comparative Statics (1)

Numerical simulations when M is given exogenously

Table 1. $\gamma=0.6$, $A=10$, $b=0.1$, $a=0.7$, $M=2$

$Pr.U$: manuf.'s profit, Mn^* : total number of goods, TQ : total quantity produced,

$Pr.D$: retailer's profit, CS : consumers' surplus, TW : total welfare

R	n^*	$Pr.U$	Mn^*	TQ	$Pr.D$	CS	TW
2	25.43	0.37	50.87	10.69	17.38	34.75	70.26
3	27.35	0.39	54.69	12.06	9.81	44.18	74.41
4	28.44	0.40	56.90	12.88	6.29	50.38	76.37
5	29.16	0.41	58.37	13.43	4.37	54.74	77.12
6	29.67	0.41	59.35	13.82	3.22	57.97	78.11
50	32.21	0.43	64.42	15.85	0.06	76.15	80.08
∞	32.6	0.44	65.20	16.17	0	79.27	80.16

V. Comparative Statics (2)

Numerical simulations when M is given exogenously

Table 2. $\gamma=0.6$, $A=10$, $b=0.1$, $M=2$, $R=4$

$Pr.U$: manuf.'s profit, Mn^* : total number of goods, TQ : total quantity produced,
 $Pr.D$: retailer's profit, CS : consumers' surplus, TW : total welfare

a	n^*	$Pr.U$	Mn^*	TQ	$Pr.D$	CS	TW
0.5	56.90	-0.004	113.8	13.1	6.47	51.82	77.72
0.6	39.06	0.171	78.1	13.0	6.39	51.15	77.07
0.7	28.45	0.226	56.9	12.88	6.29	50.38	76.37
0.8	21.68	0.675	43.4	12.75	6.19	49.52	75.64
0.9	17.12	0.99	34.2	12.61	6.08	48.60	74.88

V. Comparative Statics (3)

Numerical simulations when M is given exogenously

Table 3. $A=10$, $b=0.1$, $a=0.7$, $L=2$, $R=4$, $M=2$

$Pr.U$: manuf.'s profit, Mn^* : total number of goods, TQ : total quantity produced,

$Pr.D$: retailer's profit, CS : consumers' surplus, TW : total welfare

γ	n^*	$Pr.U$	Mn^*	TQ	$Pr.D$	CS	TW
0.2	155.1	1.13	310.3	38.52	18.79	150.3	228.1
0.3	88.94	0.88	177.9	25.66	12.51	100.1	151.9
0.4	57.95	0.65	115.9	19.26	9.39	75.13	114.0
0.5	40.10	0.50	80.2	15.42	7.53	60.24	91.4
0.6	28.44	0.40	56.9	12.88	6.29	50.38	76.4
0.7	20.11	0.31	40.2	11.08	5.42	43.40	65.7
0.8	13.6	0.24	27.2	9.73	4.78	38.24	57.8

V. Comparative Statics (4)

Numerical simulations when M is given exogenously

Table 4. $\gamma=0.5$, $A=10$, $b=0.1$, $a=0.9$, $R=2$

$Pr.U$: manuf.'s profit, Mn^* : total number of goods, TQ : total quantity produced, $Pr.D$: retailer's profit, CS : consumers' surplus, TW : total welfare

M	n^*	$Pr.U$	$M n^*$	TQ	$Pr.D$	CS	TW
2	20.9	1.17	41.8	12.45	19.85	39.70	81.75
3	13.8	0.35	41.4	12.58	20.25	40.51	82.09
4	10.2	0.15	40.9	12.62	20.38	40.77	82.15
5	8.1	0.07	40.5	12.63	20.44	40.88	82.16
6	6.7	0.04	40.1	12.64	20.47	40.95	82.15
7	5.7	0.02	39.8	12.65	20.49	40.98	82.13
8	4.9	0.01	39.6	12.65	20.50	41.01	82.10
9	4.3	0.003	39.3	12.65	20.51	41.02	82.08
10	3.9	-0.001	39.0	12.65	20.52	41.03	82.06

V. Comparative Statics (5)

Numerical simulations when M is given exogenously

Table 5. $A=10$, $\gamma=0.6$, $a=0.7$, $L=2$, $R=4$

$Pr.U$: manuf.'s profit, Mn^* : total number of goods, TQ : total quantity produced,
 $Pr.D$: retailer's profit, CS : consumers' surplus, TW : total welfare

b	n^*	$Pr.U$	Mn^*	TQ	$Pr.D$	CS	TW
0.1	28.45	0.40	56.90	56.90	6.30	50.38	74.56
0.3	14.36	0.71	28.71	28.71	5.97	47.79	73.11
0.5	10.33	0.91	20.66	20.66	5.74	45.93	71.85
0.7	8.27	1.07	16.54	16.54	5.54	44.40	70.73
0.9	6.97	1.18	13.95	13.95	5.38	43.06	66.97
1.1	6.07	1.28	12.15	12.15	5.23	41.87	65.37

VI. Numerical Simulations Findings

- As the number of manufacturers M increases we observe an decrease in:
 1. Product variety of each manufacturer (n^*)
 2. Manufacturers' profits
 3. The total number of goods produced ($M n^*$)
- The retailers' profits, the total quantity ($M n^* Q$), the consumer's surplus increase
- As the economies of scope become stronger (lower a) we observe an increase in
 1. The total number of goods produced ($M n^*$)
 2. The product variety produced by each manufacturer (n^*)
 3. The total quantity ($M n^* Q$)
 4. The retailers' profits
 5. The consumer surplus and social welfare
- While the manufacturers' profits decrease

VI. Numerical Simulations Findings

- As the degree of product substitutability γ increases we observe a decrease in:
 1. The product variety produced by each manufacturer (n^*)
 2. The total number of the goods produced (Mn^*)
 3. The total quantity (Mn^*Q)
 4. The retailers' and manufacturers' profits
 5. The consumer surplus and social welfare
- As the number of the retailers R increases we observe an increase in:
 1. The product variety produced by each manufacturer (n^*)
 2. The total number of the produced goods (Mn^*)
 3. The total quantity (Mn^*Q)
 4. The manufacturers' profits
 5. The consumers surplus.

While the retailers' profits decrease

VI. Equilibrium Analysis: Free Entry

Case 2: Free-entry in the upstream sector

There is free entry in the upstream sector, i.e. the number of manufacturers M^* is such that each manufacturer's profits are equal to zero in equilibrium, or else:

In **Stage 0** manufacturers decide to enter or not in the upstream market

Proposition 3: (i) If the economies of scope are strong enough ($0 < a \leq a_L$), then there is no symmetric equilibrium with $M > 1$, $n > 1$.

(ii) If the economies of scope are weak enough ($a_L < a_H \leq a$, $a_H < 1$) then each manufacturer produces a single good.

VI. Equilibrium Analysis: Free Entry (cont'd)

Proposition 4: For any intermediate degree of economies of scope, $a_L \leq a \leq a_H$, the equilibrium values of $M^* > 1$, $n^* > 1$ and w^* are determined by the system of equations:

$$M^* = \frac{1}{1-a} - \frac{1-\gamma}{\gamma n^*}$$

$$w^* = \frac{A(1-a)(1-\gamma)}{a\gamma n^* + (1-a)(1-\gamma)}$$

$$\frac{R}{(1+R)} \frac{A^2 a (1-a)^2 (1-\gamma) n^*}{(a\gamma n^* + (1-a)(1-\gamma))^2} = b n^{*a}$$

VI. Free Entry Results (1)

Proposition 5: For all intermediate degrees of economies of scope, $a_L \leq a \leq a_H$ the total number of goods, the total output and the retailers' profits are **higher** in the case of multi-product manufacturers than the respective ones in the case of single product manufacturers. On the contrary, the multi-product manufacturers' wholesale prices are **lower** than those in the case of single product manufacturers.

Proposition 6: (i) The number of varieties produced by each manufacturer n^* is increasing in A , R and γ and is decreasing in a and b .

(ii) The equilibrium wholesale price is inversely related to the equilibrium number of varieties produced by each manufacturer.

VII. Comparative Statics (1)

Numerical simulations under free entry upstream.

Table 6. $\gamma=0.6, A=10, b=0.1, a=0.7$

N^s, TW^s : number of firms (goods), total welfare in the case of single-product manufacturers

R	n^*	M^*	M^*n^*	N^s	TQ	$Pr. D$	CS	TW	TW^s
2	14.25	3.28	46.8	26.4	10.7	17.55	35.1	70.2	68.7
3	15.30	3.29	50.3	28.0	12.1	9.91	44.6	74.3	72.8
4	15.90	3.29	52.3	29.0	12.9	6.35	50.8	76.2	74.7
5	16.30	3.29	53.7	29.6	13.5	4.42	55.2	77.3	75.4
6	16.57	3.29	54.6	30.0	13.9	3.24	58.5	77.9	76.4
50	17.97	3.29	59.2	32.2	15.9	0.06	76.8	79.8	78.2
∞	18.18	3.30	59.9	32.5	16.2	0	79.9	79.9	78.3

VII. Comparative Statics (2)

Numerical simulations under free entry upstream.

Table 7. $\gamma=0.6, A=10, b=0.1, R=4$

Pr.U: manuf.'s profit, M^*n^* : total number of goods, *TQ*: total quantity produced, *Pr.D*: retailer's profit, *CS*: consumers' surplus, *TW*: total welfare

a	n^*	M^*	M^*n^*	<i>TQ</i>	<i>Pr. D</i>	<i>CS</i>	<i>TW</i>
0.1	3200	1.11	3555	13.30	6.64	53.12	79.7
0.3	268.2	1.42	382.4	13.23	6.58	52.63	78.9
0.5	57.4	1.98	114.0	13.10	6.48	51.81	77.7
0.7	15.9	3.29	52.34	12.93	6.35	50.82	76.2
0.9	3.25	9.79	31.93	12.77	6.24	49.95	74.9

VII. Comparative Statics (3)

Numerical simulations under free entry upstream.

Table 8: $A=10, b=0.1, a=0.7, R=4$

$Pr.U$: manuf.'s profit, M^*n^* : total number of goods, TQ : total quantity produced, $Pr.D$: retailer's profit, CS : consumers' surplus, TW : total welfare

γ	n^*	M^*	M^*n^*	TQ	$Pr.D$	CS	TW
0.5	22.44	3.29	73.81	15.49	7.60	60.8	91.2
0.6	15.90	3.29	52.34	12.93	6.35	50.8	76.2
0.7	11.22	3.30	36.97	11.12	5.46	43.8	65.6
0.8	7.57	3.30	25.00	9.76	4.81	38.5	57.7
0.9	4.40	3.30	14.57	8.72	4.31	34.5	51.8

VII. Comparative Statics (4)

Numerical simulations under free entry upstream.

Table 9: $\gamma=0.6, A=10, R=4, a=0.7$

$Pr.U$: manuf.'s profit, M^*n^* : total number of goods, TQ : total quantity produced, $Pr.D$: retailer's profit, CS : consumers' surplus, TW : total welfare

b	n^*	M	M^*n^*	TQ	$Pr.D$	CS	TW
0.1	15.9	3.29	52.34	12.93	6.35	50.82	76.23
0.3	8.17	3.25	26.57	12.57	6.07	48.57	72.86
0.5	5.96	3.22	19.21	12.29	5.87	46.94	70.41
0.7	4.83	3.20	15.43	12.07	5.69	45.57	68.36
0.9	4.12	3.17	13.07	11.86	5.54	44.37	66.56

VIII. Numerical Simulations Results

- As the economies of scope become stronger, the product variety produced by each manufacturer, n^* , the total number of goods, Mn^* , the total output, Mn^*Q , the retailers' profits, the consumer surplus and the social welfare increase, while the number of manufacturers decreases.
- As the degree of product substitutability γ increases, the product variety produced by each manufacturer, n^* , the total number of goods, Mn^* , the total output, Mn^*Q , the retailers' and manufacturers' profits, and the consumers' surplus and the social welfare decrease. Finally, it has only minor positive impact on the equilibrium number of manufacturers.
- An increase in the number of retailers, R , leads to an increase in the product variety produced by each manufacturer, n^* , the total number of goods, Mn^* , the total output, Mn^*Q , the consumers' surplus and the total welfare, while it leads to a decrease in the retailers' profits. Finally, it has only minor positive impact on the equilibrium number of manufacturers.

XII. Conclusions

- We have developed a successive oligopoly model where multi-product manufacturers sell their differentiated goods to a given number of retailers, which in turn resell them to final consumers.
- Both the cases of fixed number of firms upstream and free-entry upstream are analyzed.
- Particular emphasis is given on the role of the economies of scope in the product creation process.
- The effect of various market features (i.e. product substitutability, number of retailers, size of the market) on equilibrium market outcomes (i.e. wholesale prices, product variety, number of manufacturers etc.) and on welfare is investigated.

THANK YOU

