PART II: FIRM LEVEL PERFORMANCE AND OPENNESS: A CLOSER LOOK

Rather than treat the distribution of marginal costs as exogenously given, it seems more realistic to think of it as responding to a country's openness. This might happen for a variety of reasons:

1. Induced innovation
   - due to factor price effects (Grossman and Helpman, 1991) and
   - due to the intensity of competition (Aghion and various co-authors);

2. Learning by doing (Lucas, 1988; Young, 1991);

3. International knowledge diffusion (Grossman and Helpman, 1991).

I. INNOVATION AND COMPETITIVE PRESSURES

How does this competitive pressure affect innovation? There are several possible mechanisms: principal agency problems, Schumpeterian profit squeezes, and incentives to distance one's own firm from competitors. We'll focus on the latter two.

A. Theory

Aghion, P., C. Harris, P. Howitt and J. Vickers (2001, *Review of Economic Studies*)

<u>Demand</u>

Suppose representative consumer has utility function $U = \int_0^1 \ln(x_j)dj$, where x_j is an index of consumption of goods from industry *j*. More precisely, suppose each industry is serviced by two firms, *A* and *B*, and let $x_j = \left(x_{A_j}^{\alpha_j} + x_{B_j}^{\alpha_j} \right)^{\frac{1}{\alpha_j}}$, $0 < \alpha \le 1$. Because utility is Cobb-Douglas in *x*'s, each industry will receive the same share of total expenditure, which we normalize to unity. Thus in each industry, consumers choose the combination of the to goods that maximizes x_j, subject to $P_{A_j} x_{A_j} + P_{B_j} x_{B_j} = 1$. The usual expressions for demand obtain:

$$x_{A_j} = \frac{P_{A_j}^{\frac{1}{\alpha_j - 1}}}{P_{A_j}^{\frac{\alpha_j}{\alpha_j - 1}} + P_{B_j}^{\frac{\alpha_j}{\alpha_j - 1}}}, \quad x_{B_j} = \frac{P_{B_j}^{\frac{1}{\alpha_j - 1}}}{P_{A_j}^{\frac{\alpha_j}{\alpha_j - 1}} + P_{B_j}^{\frac{\alpha_j}{\alpha_j - 1}}}.$$

Hereafter we shall suppress *j* subscripts.

Spot market equilibria

Consider only Markov-perfect equilibria and suppose Bertrand competition in product markets. To obtain profit expressions, first define revenue for the i^{th} firm as

$P_i x_i \equiv \lambda_i = \dfrac{P_i^{\frac{\alpha}{\alpha-1}}}{P_A^{\frac{\alpha}{\alpha-1}} + P_B^{\frac{\alpha}{\alpha-1}}}$. Then each firm's equilibrium price is given by the usual

mark-up over marginal cost, $P_i = \left(\dfrac{\eta_i}{\eta_i - 1}\right) c_i = \dfrac{1-\alpha\lambda_i}{\alpha(1-\lambda_i)} c_i$, and each earns profits

$\pi_i = \dfrac{\lambda_i}{\eta_i} = \dfrac{\lambda_i(1-\alpha)}{1-\lambda_i\alpha}$. Note that since $0 < \alpha \leq 1$, larger firms charge larger mark-ups, as usual, and earn larger profits. Firms are big because they have low costs. In fact, it is possible to show with a bit of grinding that profits depend *only* on relative costs, and the parameter, α: $\pi_A = \phi(c_A / c_B, \alpha)$, $\pi_B = \phi(c_B / c_A, \alpha)$. (See appendix to Agion et al, 2001) Bigger α means a higher elasticity of substitution among goods, and lower profits.

Innovation

Suppose that the labor requirements per unit of output by firm *i* are given by $c_i = \gamma^{-k_i}$, $\gamma > 1$, where k_i indicates the number of innovative steps that this firm has taken. Also, define π_m to be the profits of a firm that is in front by *m* steps, and π_{-m} to be the profits of a firm lagging by *m* steps. The case of $m = 0$ is a "neck and neck" industry.

For the leading firm, innovative steps occur with instantaneous hazard rate *n*, and cost $\varphi(n) = \beta n^2$ units of labor. For the lagging firm, innovative steps occur with hazard rate *h* + *n*, and cost $\varphi(n) = \beta n^2$, where *h* is the probability that the lagging firm will be able to imitate the leading firm without doing any R&D itself.

Let V_m be the steady state value of a firm leading by *m* steps and let *w* be the (exogenous) wage rate. Then the following Bellman equation obtains:

$$V_m = \max_n \left\{ \begin{array}{l} \left(\pi_m - w\beta n_m^2 / 2\right)dt \\ + e^{-rdt}\left[n_m dt V_{m+1} + (n_{-m} + h)dt V_{m-1} + \left(1 - n_m dt - (n_{-m} + h)dt\right)V_m\right] \end{array} \right\}$$

Given that $ln(1\text{-}rdt) \approx \text{-}rdt$ for small *dt*, we have $e^{-rdt} \approx 1 - rdt$. Substituting this expression and dropping dt^2 terms (which are second order small), we obtain:

$$rV_m = \pi_m + n_m(V_{m+1} - V_m) + (n_{-m} + h)(V_{m-1} - V_m) - w\beta\left(n_m\right)^2 / 2 \qquad (1)$$

Similarly, for the lagging firm we obtain:

$$rV_{-m} = \pi_{-m} + n_m(V_{-m-1} - V_{-m}) + (n_{-m} + h)(V_{-m+1} - V_{-m}) - w\beta(n_{-m})^2/2, \tag{2}$$

and for neck-and-neck firms:

$$rV_0 = \pi_0 + n_0(V_1 - V_0) + n_0(V_{-1} - V_0) - w\beta(n_0)^2/2. \tag{3}$$

Since each type of firm chooses its R&D intensity to maximize its current value, these intensities must satisfy:

$$\beta w n_m = V_{m+1} - V_m, \quad \beta w n_{-m} = V_{-(m-1)} - V_{-m}, \quad \beta w n_0 = V_1 - V_0 \tag{4}$$

Solving for *n*'s and substituting back into (1)-(3) yields a system of equations that can be used to identify values, once profits are known. To get analytical expressions, we'll solve the model for the case where firms can get a maximum of one step apart. This corresponds to the case where an innovation conveys a very large advantage, making the leading a firm a near monopolist with no incentive to further increase its advantage. More general cases can be solved numerically and appear to have the same properties. Setting $w = \beta = 1$, $h = 0$ (no spillovers, infinitely elastic supply of labor), and noting that $n_1 = 0$, equations (1)-(3) evaluated at the *n*'s implied by lead to:

$$rV_1 = \pi_1 + n_{-1}(V_0 - V_1)$$
$$rV_{-1} = \pi_{-1} + n_{-1}(V_0 - V_{-1}) - (n_{-1})^2/2$$
$$rV_0 = \pi_0 + n_0(V_1 - V_0) + n_0(V_{-1} - V_0) - (n_0)^2/2$$

and equations (4) imply:

$$n_{-1} = V_0 - V_{-1}$$
$$n_0 = V_1 - V_0$$

Together, these 5 equations allow one to eliminate the *V*'s and find innovation rates as functions of profits for the different types of firms. (Recall that $n_1 = 0$.

$$\frac{n_0^2}{2} + rn_0 - (\pi_1 - \pi_0) = 0$$
$$\frac{n_{-1}^2}{2} + (r + n_0)n_1 - (\pi_0 - \pi_{-1}) - \frac{n_0^2}{2} = 0$$

These equations imply:

$$n_0 = -r + \sqrt{r^2 + 2(\pi_1 - \pi_0)} \text{ and } n_{-1} = -(r + n_0) + \sqrt{r^2 + (n_0)^2 + 2(\pi_1 - \pi_{-1})}$$

Shocks to competitive pressure thus affect leading and following firms differently. Suppose a change in the degree of competitive pressure reduces profits for neck and neck firms, leaving leading and following firm profits unchanged. Neck and neck innovation intensity increases, while lagging firm innovation falls. The former effect is due to the incentive to distance one's firm from the competition; the latter is due to Schumpeterian rent squeezing.

Numerical solutions for particular parameter values, using the more general version of the model and shocks to the elasticity of substitution, show qualitatively similar results.

How does trade figure in? Loosely speaking, opening to trade may induce increases in the elasticity of substitution by introducing substitute varieties. Firms competing in global markets have less market power. (More work remains to be done to integrate foreign competition into this class of model.)

On the basis of the discussion thus far, we'd expect to find that industries with neck and competition respond with productivity growth to competitive pressures, while industries with leaders and followers would tend to reduce innovation. One might therefore expect the market shares of the two types of industries to determine the aggregate innovation rate.

But changes in the degree of competition are likely to change the shares themselves. Let μ_1 (μ_0) be the steady state probability of being an unleveled (leveled) industry. The probability of movement to leveled is $\mu_1 n_{-1}$ = (share) × (innovation rate) among lagging firms, and the probability of movement *from* a leveled industry is $2\mu_0 n_0$. In steady state these must match. Using that fact, and the constraint that shares must sum to 1, the average flow of innovations must be:

$$I = \mu_0 2n_0 + \mu_1 n_{-1} = 2\mu_1 n_{-1} = \frac{4n_0 n_{-1}}{2n_0 + n_{-1}}$$

Thus, as the neck and neck profit rate fall, the average innovation rate may respond non-monotonically. For specific parameter values, Aghion et al (2002) demonstrate an inverted-U pattern relating the degree of competition to the rate of innovation. The key point is that in leveled states, *both* firms have an incentive to innovate. Industries that spent most of their time in leveled states thus show high average rates of innovation.

- When competition is slight, it doesn't matter much what one's competitor is doing, so π_0 is relatively close to π_1. There is little incentive for firms to innovate when the sector is leveled. But when the sector is unleveled, the laggard firm has a relatively strong incentive to innovate, so the industry reverts to leveled states relatively quickly.

- When competition is very high π_0 is relatively close to π_{-1}, so there is relatively little incentive for the laggard in an unleveled state to innovate, and the industry will be slow to leave unleveled states. On the other hand, the gap between so π_0 and π_1 is large, so in leveled states someone quickly innovates. The industry spends most of its time unleveled, where the leader never innovates.

Now let's consider the empirical evidence concerning these mechanisms. Since we just finished talking about competition-induced learning, we'll begin with this.

B. Evidence

Aghion, Burgess, Redding and Zilibotti (2003)
India underwent a significant trade liberalization during the period 1990-97. Between 1990 and 1992, average tariffs fell by 22 percentage points, with some products experiencing reductions of 235 points. Further reductions occurred during 1992-97 for a cumulative reduction of 51 percentage points, on average. (See Aghion, et al 2003, table 1, appendix p. 1.) Foreign competition was also liberalized in the form of FDI (figure 2, appendix p 10), and regulations requiring industrial licensing were scaled back, although regulations remained for 18 broad categories of industries. Also, the degree to which state-specific regulations were pro-worker remained variable, and subject to ongoing intra-state change.

Aghion et al (2001) suggests that trade liberalization should affect different states differently, depending upon how competitive they were on the eve of the reforms. Firms and industries that were close to the global technological frontier on the eve of the reforms should have heightened incentives to invest in innovation when they are integrated with the global economy; laggard sectors should be discouraged from innovation. Whether labor regulation forces owners to share rents from innovation should also matter.

The model: $Y_{sit} = \alpha(X_{si} \cdot R_t) + \beta Z_{st} + \gamma(Z_{st} \cdot R)_t + \delta C_{sit} + \eta_{si} + \mu_t d_t + u_{sit}$

Let *s*, *i*, and *t* index state, industry, and time. Y is an economic measure of interest (e.g., labor productivity), X is a measure of how close a state-industry was to the technological frontier pre-reform; R is a dummy for the reform period; Z is a measure of state-level institutions (direction of labor regulations); C is a vector of control variables, d is a vector of time dummies and η is an industry fixed effect. X is the main variable of interest. A variant of this model distinguishes "high" and "low" reform industries according to the magnitude of their median tariff reductions, absence of compulsory licensing and absence of restriction to public sector activity after 1991.

Findings: Distance to the frontier is the state's position in the pre-reform distribution of productivity within the industry. To control for measurement error that may be correlated with industry size, the regression results use weighted least squares, with log time-averaged state-industry employment as weights.

When performance is measured using labor productivity, state industries closer to the technological frontier pre-reform experienced statistically significant larger increases in real manufacturing output per worker. (Column 1, table 2)

Adding controls for pro-worker legislation (Column 2, table 2), more pro-worker labor regulation within a state reduces real manufacturing output per employee. The negative effect of pro-worker legislation is stronger post-liberalization (column 3, table 2). Table 3 redoes the analysis with TFP in place of labor productivity. The results are similar.

Liberalization and labor productivity in India

	(1)	(2)	(3)
	Ln(*Y/L*)	*Ln*(*Y/L*)	*Ln*(*Y/L*)
Pre-reform proximity × reform	0.165 (0.045)	0.158	0.162
		(0.045)	(0.044)
Labor regulation		-0.042	-0.032
		(0.010)	(0.010)
Labor regulation × reform			-0.012
			(0.004)
State industry fixed effects	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Observations	19623	19623	19623
R-squared	0.83	0.83	0.83
P value	0.000	0.000	0.000

Liberalization and total factor productivity in India

	(1)	(2)	(3)
	Ln(*Y/L*)	*Ln*(*Y/L*)	*Ln*(*Y/L*)
Pre-reform proximity × reform	0.096	0.084	0.096
	(0.037)	(0.036)	(0.035)
Labor regulation		-0.071	-0.038
		(0.014)	(0.013)
Labor regulation × reform			-0.041
			(0.005)
State industry fixed effects	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Observations	18,528	18,528	18,528
R-squared	0.60	0.60	0.61
P value	0.000	0.000	0.000

<u>Source:</u> Table 3, Aghion, Burgess, Redding and Zilibotti (2003)

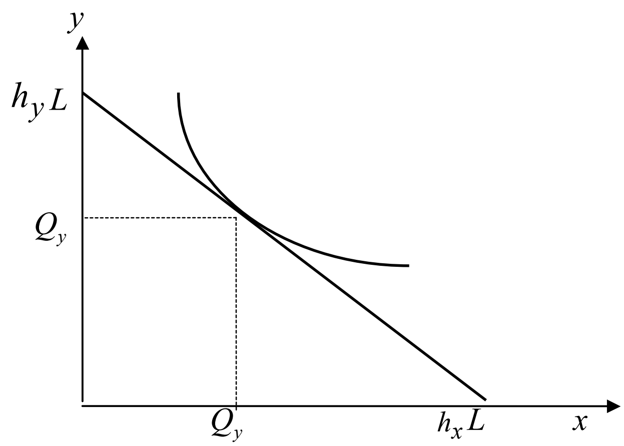
II. SPILLOVERS AND LEARNING BY DOING

a) A simple model of growth-enhancing infant industry protection (Lucas, 1988)

Suppose two sectors, CRS, labor is the only input. The production technology is thus:

$$Q_x = h_x L_x, \quad Q_y = h_y L_y \text{ where}$$
$$L_x = uL, \quad L_y = (1-u)L$$

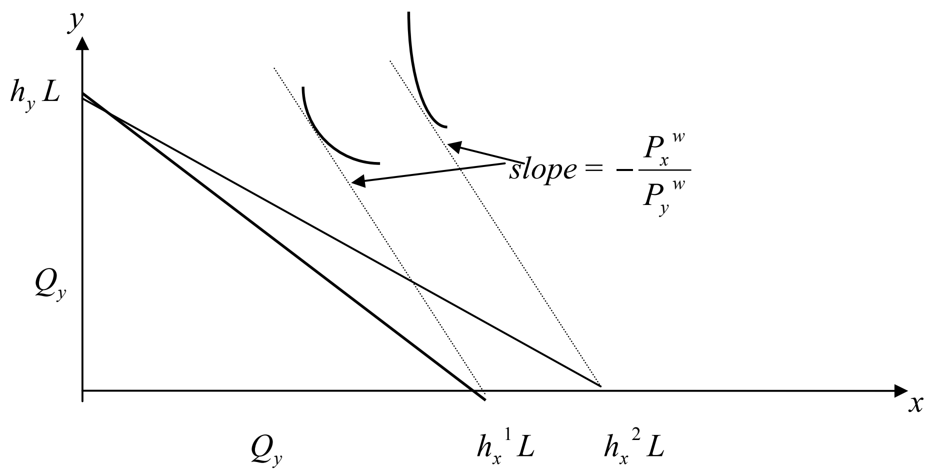
Production possibilities frontier, and autarky production point



At the autarky equilibrium, prices are dictated by the technology: $\frac{P_x}{P_y} = \frac{h_y}{h_x}$. The more time is devoted to *x* production, the higher is h_x, and likewise for *y*.
But learning is relatively rapid in *y*: $\frac{\dot{h}_x}{h_x} = u\delta_x, \frac{\dot{h}_y}{h_y} = (1-u)\delta_y$, where $\delta_x < \delta_y$. (All learning is in the public domain, so producers don't plan their production to generate private knowledge for themselves.) So if domestic tastes favor *x*, productivity grows slowly.

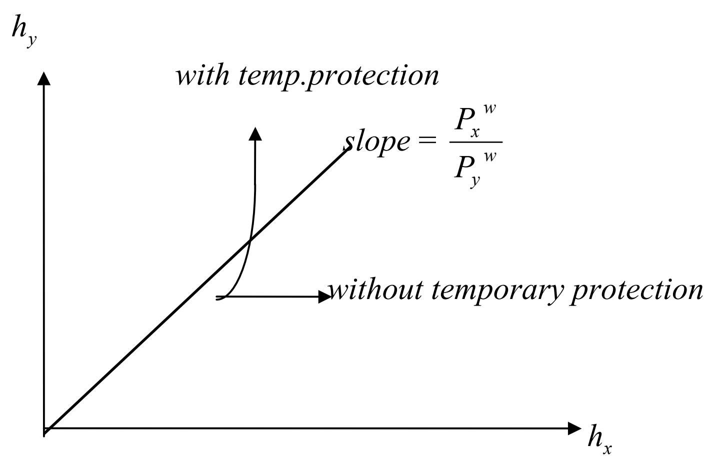
Now consider opening to trade. World prices will determine whether the country specializes in *x* or *y*, in accordance with the country's comparative advantage. Suppose world prices are such that the country has a comparative advantage in *x*: $\frac{P_x^{\ w}}{P_y^{\ w}} > \frac{h_y}{h_x}$.

Thereafter the country produces only *x*:



For *any* $\frac{P_x^w}{P_y^w} > \frac{h_y}{h_x}$, opening to trade permanently arrests productivity growth in the *y* sector.

On the other hand, suppose the country promotes the *y* sector sufficiently that the PPF becomes steeper over time as learning takes place relatively rapidly in *y* goods. If it gets to the point where $\frac{P_x^w}{P_y^w} < \frac{h_y}{h_x}$, a comparative advantage in *y* goods has been established, and opening to trade will lock the country into specialization in the good with rapid learning.



To be more explicit about the dynamics under autarky, we need to model preferences. Assume CES (Dixit-Stiglitz) tastes:

$$W(c_x, c_y) = \left[\alpha_x c_x^{\rho} + \alpha_y c_y^{\rho}\right]^{\frac{1}{\rho}}$$

where the elasticity of substitution is $\sigma = \frac{1}{1-\rho}$. Suppose σ>1, so that the two goods are close substitutes for one another. Then if $\frac{h_y}{h_x}$ rises under autarky, causing the domestic price of *x* to rise relative to the price of *y*, consumers will shift consumption more than proportionately toward *y* production. This will induce an increase in demand for labor in the *y* sector, even though h_y is rising, so there will be further increases in $\frac{h_y}{h_x}$. The country will move toward specialization in the good it starts out producing.

Formally, define $\frac{p_y}{p_x} = q$ as the relative price of *y*, and represent the static equilibrium as:

$$q = \frac{W_y}{W_x} = \left(\frac{\alpha_y}{\alpha_x}\right)\left(\frac{c_y}{c_x}\right)^{-(1-\rho)}, \text{ or } \left(\frac{c_y}{c_x}\right) = \left(\frac{\alpha_y}{\alpha_x}\right)^{\sigma} q^{-\sigma}.$$

Profit maximization ensures that $q = \frac{h_x}{h_y}$ in autarky, so market clearing implies:

$$\frac{y}{x} = \frac{(1-u)h_y}{uh_x} = \frac{c_y}{c_x} = \left(\frac{\alpha_y}{\alpha_x}\right)^{\sigma}\left(\frac{h_y}{h_x}\right)^{\sigma}, \quad \frac{1-u}{u} = \left(\frac{\alpha_y}{\alpha_x}\right)^{\sigma}\left(\frac{h_y}{h_x}\right)^{\sigma-1}, \text{ or}$$

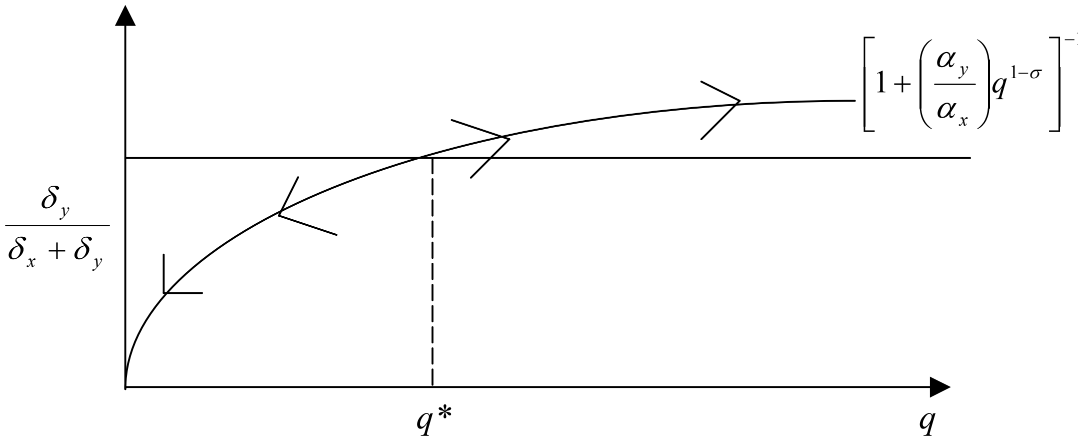
$$u = \left[1 + \left(\frac{\alpha_y}{\alpha_x}\right)^{\sigma}\left(\frac{h_y}{h_x}\right)^{\sigma-1}\right]^{-1} = \left[1 + \left(\frac{\alpha_y}{\alpha_x}\right)^{\sigma} q^{1-\sigma}\right]^{-1}$$

Finally, growth in *q* is governed by:

$$\frac{\dot{q}}{q} = \frac{\dot{h}_y}{h_y} - \frac{\dot{h}_x}{h_x} = \delta_x u - \delta_y(1-u) = (\delta_x + \delta_y)u - \delta_y = (\delta_x + \delta_y)\left[1 + \left(\frac{\alpha_y}{\alpha_x}\right)^{\sigma} q^{1-\sigma}\right]^{-1} - \delta_y$$

The right-hand side is a positive function of *q* when our assumption of σ > 1 is true.

Hence, above some threshold value, q exhibits continual growth, and below that value it always shrinks. To find the critical value, set q growth to zero and solve for q:



Autarky, beginning from any q below q^*, will result in a falling relative price of y due to relatively rapid technological growth in the y sector.

(Its possible to endogenize world prices and look at the global equilbrium—we won't bother.)

b) Learning by doing with a continuum of goods (Young, 1991)

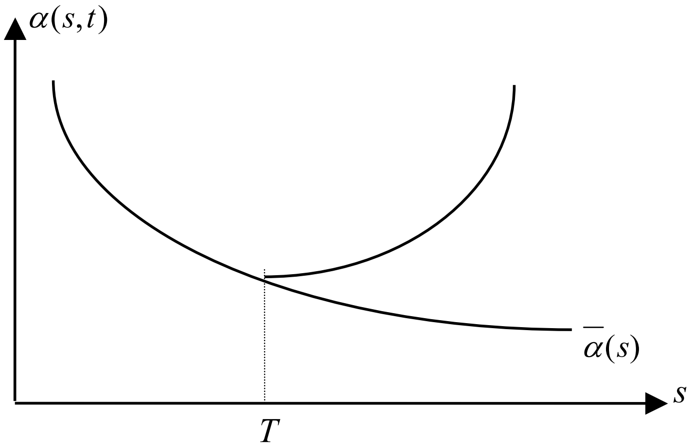
Production
There is a continuum of potentially producable goods, indexed by: $s \in [B,\infty]$. To produce a unit of good s at time t requires $\alpha(s,t)$ units of labor (and nothing else). The continuum of goods is divided into two regions at T_t, which is a function of time:

$s < T$ (no learning)
$s > T$ (learning and spillovers)

$$\alpha(s,t) = \begin{cases} \bar{\alpha}e^{-s} & if \;\; s \le T \\ \bar{\alpha}e^{-T}e^{s-T} & if \;\; s \ge T \end{cases}$$

Implications?

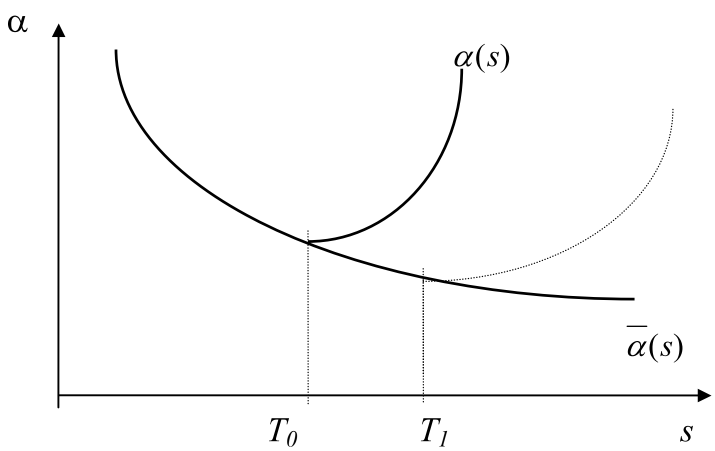
- The greater the sophistication of the good, the greater potential efficiency, once learning effects are exhausted.
- Among goods with unexhausted learning possibilities, labor requirements are positively related to their sophistication
- Among goods with learning, efficiency improves at the common rate: $\frac{\partial \ln \alpha}{\partial t} = -2\frac{dT}{dt}$



How is this the rate of efficiency growth determined? It is directly related to the amount of labor employed in the learning sectors:

$$\frac{dT}{dt} = \int_T^\infty L(s,t)ds, \quad \text{so}$$

$$\frac{\partial \ln \alpha(s,t)}{\partial t} = \begin{cases} -2\frac{dT}{dt} = -2\int_T^\infty L(v,t)dv & \forall\ s > t \\ 0 & \forall\ s \le t \end{cases}$$



Pricing

The returns to knowledge creation through learning cannot be internalized, so given the constant returns technology, pricing is competitive: $P_s = w\alpha(s,t)$.

Note that as the average efficiency of the bundle of goods produced rises (i.e., the relevant range of the $\alpha(s,t)$ schedule falls), the wage rate rises relative to prices.

Demand

At each point in time, let instantaneous utility be $V = \int_B^\infty \ln[C(s)+1]ds$, where *C(s)* denotes instantaneous consumption of good *s,* and s indexes the technological sophistication of the good.

There is no storage, so at each point in time consumers spend all their income and the usual first order conditions for static utility maximization apply. Each consumer solves:

$$\max_{C(\cdot)} V = \int_B^\infty \ln[C(s)+1]ds$$

$$s.t.$$

$$w = \int_B^\infty C(s)w\alpha(s)ds \quad or \quad 1 = \int_B^\infty C(s)\alpha(s)ds.$$

Among all goods consumed,

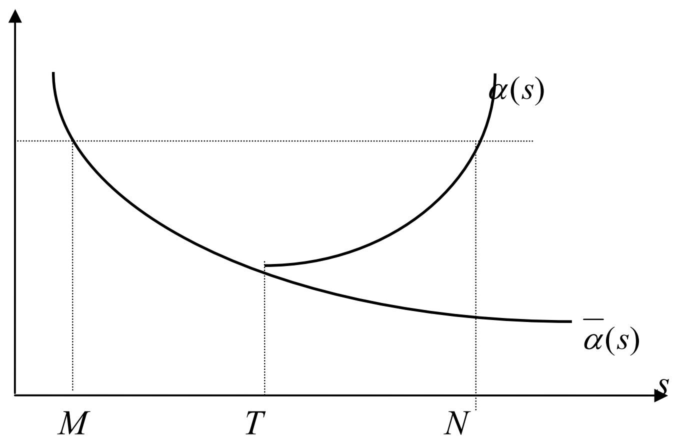
$$\frac{MU_S}{MU_{S'}} = \frac{C_{S'}+1}{C_S+1} = \frac{P_S}{P_{S'}} = \frac{\alpha(s)}{\alpha(s')} \quad .$$

Some goods are so expensive that they aren't consumed at all. Call the low-tech good on the margin between and positive consumption good *M,* and the high-tech good on this margin good *N.* Then,

$$\frac{1}{C_S+1} = \frac{P_S}{P_M} = \frac{\alpha(s)}{\alpha(M)}, \text{ or:}$$

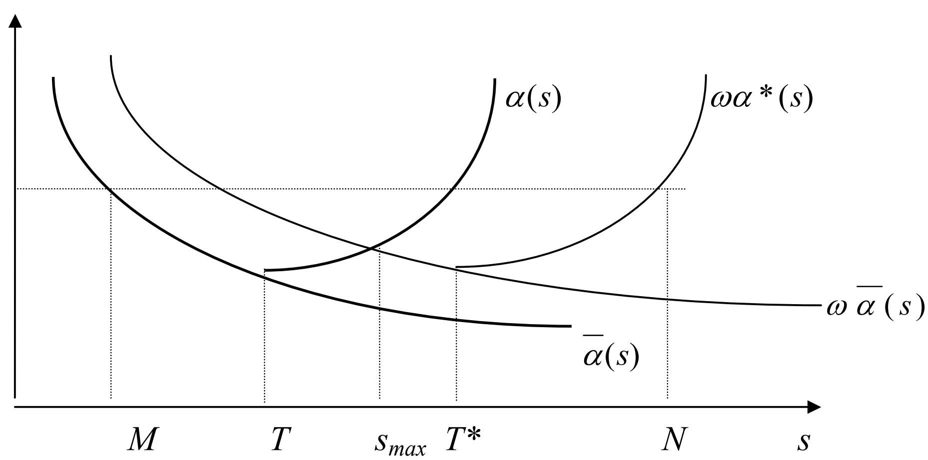
$$\alpha(s)C_s = \alpha(M) - \alpha(s).$$

An analogous expression holds for good *N.* In autarky, therefore, the amount of labor devoted to each good consumed is the vertical distance to the horizontal line at height $\alpha(M)$. Also the total labor force is the area in the "cup."



The rate of change in T is *L/2,* and this is also the rate of growth in GDP per capita. As productivity increases, the "cup" drifts downward to the right, and real wages rise.

Now suppose that trade is opened up with a country (*) that is further along ($T^* > T$) and has a higher wage $w^* = \omega w$. Then the menu of alternative goods available in the South will be:



(Other configurations are possible, depending upon relative size and tech. gap.)

- The LDC high-end goods are undercut by the more advanced DC s.
- Trade thus shifts the labor force toward goods with no learning potential, and less spillovers take place. Growth slows in the LDCs.
- In the DC s, production of the low end goods is undercut by the low-wage LDC. So there, labor is shifted toward goods with high learning potential and spillovers.

c. Evidence from the microchip industry

Is learning by doing also important? The evidence is limited, but in those industries that have been closely studied, it appears to be. Perhaps the two most studies examples are microchips and shipbuilding.

Irwin and Klenow (*Journal of Political Economy, 1994*)

New varieties of microchips that dynamic random access memory (DRAM) have been frequently introduced. At the time of IK's article, 8 generations had hit the market: 4K, 16K, 16K-5, 64K, 1M, 4M, and 16M. Each generation involved a new technology, and each technology involved learning. (Refer to Figure 1, IK). Over the period 1974-1992, most production came from about 30 firms in the US and Japan. (Refer to table A1.)

Because the US and Japan both believed that the learning effects in this industry were important, each worried about Lucas-type lock-in during the 1980s. That is, both wanted to become the global low cost producer, and neither wanted to lose its foothold in the market. To facilitate rapid learning in the early 1980s, "Japan's government-owned Nippon Telegraph and Telephone (NTT) transferred device designs and production technologies of 64K and 256K DRAMS to other Japanese firms." For its part, the US negotiated the 1986 Semiconductor Trade Arrangement with Japan, which compelled the Japanese government to encourage Japanese firms to reduce output, and retaliated with trade barriers against Japanese microchips after 1987 for "failure to comply with the agreement."

For a particular generation of DRAM, IK approximate the cost technology in microchips with the function

$$c_i = \upsilon_i E_{it}^{\beta} e^{u_{it}} ,$$

where

$$E_{it} = Q_{it} + \alpha(Q_{ct} - Q_{it}) + \gamma(Q_{wt} - Q_{ct}),$$

and $u_{it} = \mu + \alpha t + \rho u_{it-1} + \varepsilon_{it}$. Here Q_{it} is the cumulative output of the i^{th} firm, Q_c is the cumulative output of country *c*, and Q_w is the cumulative output of the world. The serially correlated disturbance is intended to pick up factor price shocks, and the firm-specific intercept picks up permanent differences in firm/managerial quality.

The cases of pure internal learning (α=γ=0), learning external to the firm but internal to the country (α=1, γ=0), and learning external to the firm and the country (α=1, γ=1) are nested here (among others).

Assuming that the spot market for a given generation of DRAM clears at each point in time, that firms never hit capacity constraints (controversial), and that firms Cournot compete (why Cournot?), IK characterize behavior at time zero as choosing their own output levels to maximize:

$$E_0 \sum_{t=0}^{\infty} \left(\frac{1}{1+r} \right)^t \left[p(y_t) \cdot y_{it} - c_{it} y_{it} \right]$$

subject to the marginal cost specification described above. The first-order condition is:

$$p_0 \left(1 + \frac{s_{i0}}{\eta} \right) = c_{i0} + E_0 \left[\sum_{t=1}^{\infty} \left(\frac{1}{1+r} \right)^t \cdot y_{it} \cdot \frac{\partial c_{it}}{\partial y_{i0}} \right] \equiv c_{i0}^*$$

Note that the right-hand side reflects the fact that firms take into consideration the effect of their current production levels on their future marginal costs. This first-order condition implies Euler equations of the form:

$$E_t \left\{ p_t \left(1 + \frac{s_{it}}{\eta} \right) - c_{it} - \left(\frac{1}{1+r} \right) \cdot \left[y_{it+1} \cdot \frac{\partial c_{it+1}}{\partial y_{it}} + p_{t+1} \cdot \left(1 + \frac{s_{it+1}}{\eta} \right) - c_{it+1} \right] \right\} = 0$$

DRAM prices and firms' market shares are available from industry records, and the cost function and its partial derivatives with respect to output next period come from the cost specification above. So at any given demand elasticity and set of cost function/spillover parameters, the arguments of this expectation operator are observable as a panel of disturbances—call them $\xi_{it+1}'s$. The objective is to estimate the spillover parameters, using the properties of the $\xi_{it+1}'s$.

The $\xi_{it+1}'s$ represent optimization errors due to surprises—that is, information that was not available to firms when they made their output decisions in time *t*. Hence they should be orthogonal to all elements of firms' information set in period *t*, including "a time trend, seasonal dummies, lagged endogenous variables, exchange rates, and downstream demand in the form of computer output in the United States and Japan." These orthogonality conditions provide a basis for GMM estimation of the unknown parameters. (The elasticity of demand is set at 1.8.)

The results are reported in table 2. Estimates for internal learning are fairly precise, but α and γ estimates are less so. Taken at face value, the point estimates imply a role for both types of spillover—national and international, and they suggest that these sources of learning are about ¼ to ½ as important as internal learning.

Is the imprecision of spillover estimates a problem with instruments, or don't learning spillovers matter? (One strategy, not pursued, would be to pool information across

DRAM generations.) IK reformulate their cost function in terms of c^*: That is, they assume that dynamic marginal cost rather than current marginal cost evolves with experience: $c_{it}^* = vE_i^{\beta} e^{u_i}$ Now the ξ_{it}'s simply reflect exogenous cost shocks, and no instruments are required, although serial correlation corrections are advisable.

Tables 3 and 4 report findings. Own learning rates are about the same, as are spillover parameters, but the precision of the estimates improves. (This could reflect neglect of serial correlation.) Still, firms are learning about .30 as much from a unit of external production as from a unit of own production. Global and national spillovers are very similar, so borders don't seem to matter much.

Note, however, that cumulative external production is typically more than three times as much as cumulative own production, so the effect of knowledge generated elsewhere on own productivity is important.

What about cross-generation spillovers of the type modeled by Young (1991)? Define

$$E_{it} = Q_{it} + \omega(Q_{wt} - Q_{it}) + \varphi\left[\tilde{Q}_{it} + \omega\left(\tilde{Q}_{iw} - \tilde{Q}_{it}\right)\right]$$

where tildes indicate cumulative production of the *previous* DRAM generation. Table 7 shows that for several chips (16K, 64K and 1M), these intergenerational spillovers may have been important. But they appear to be insignificant for the others.

So the promotion of the microchip industry may or may not have cumulative long term learning benefits.

Limitations of study? (entry/exit, endogenous introduction of next generation)

d. Evidence from the shipbuilding industry

Thorton and Thompson (*American Economic* Review, 2001)

During WWII (1939-45), the US Maritime Commission commissioned a large number of cargo ships from a number of shipbuilders. It took delivery of 5,777 vessels, including 2,707 Liberty cargo ships from a variety of shipyards. Learning in the construction of the fairly standardized Liberty ships has been well documented; Thorton and Thomspon add to the literature by using a more detailed data set and looking at spillovers.

The model:

$$\ln q_{ijk} = A_{jk} + \alpha \ln K_{ijk} + \beta \ln L_{ijk} + \gamma T_{ijk} - f(E_{ijk}) + \varepsilon_{ijk}$$

where q_{ijk} is unit labor requirements for i^{th} ship, design j, from yard k; A is design and yard dummy, K is capital, T is a time index corresponding to the date when the keel as laid, and E is a vector of experience measures:

E_1 = prior experience in the same yard on the same design
E_2 = prior experience in the same yare on other designs
E_3 = average prior experience in other yards on the same design
E_4 = average prior experience in other yards on other designs

The results we will focus upon are based on non-parametric estimation of an additively separable version of the function $f(\ )$:

$$f(E_{ijk}) = f_1(E_{1ijk}) + f_2(E_{2ijk}) + f_3(E_{3ijk}) + f_4(E_{4ijk})$$

Refer to results in figure 3.

- As expected a large positive effect of own yard learning on same design
- Within yard cross-product spillovers (mislabeled) are modest, but present
- Cross-yard within product spillovers are substantial, albeit not as large as within-yard.
- Cross-yard, cross-product spillovers are modest but present.

Although the cross-yard spillovers are modest per unit of experience, cumulative production experience at other yards combined is typically much larger. Thus, although individual yards needn't worry about the externality they are creating with additional hours of work, they benefit substantially from the combined experience of others. Calculations in table 5 show that cross-yard within-design spillovers are about as important as within-yard, within-design learning effects.

In sum, while micro studies indicate the public knowledge pool certainly matters, firms have substantial incentives to invest in their own learning-by-doing. Specifications like Young (1991) and Lucas (1988) that treat all knowledge as public domain (within a country) are too simple.

Also, the idea that industries can develop permanent technology leads and comparative advantage by getting a head start on learning may not be correct. Cross-design within-industry, within-country learning spillovers appear to be limited in both DRAM chips and ships.

e. Knowledge diffusion through exports

Clerides, Lach and Tybout (*Quarterly Journal of Economics,* 1998)

Many analysts believe that firms become more efficient by becoming exporters: Participating in export markets brings firms into contact with international best practice and fosters learning and productivity growth (World Bank, 1997).

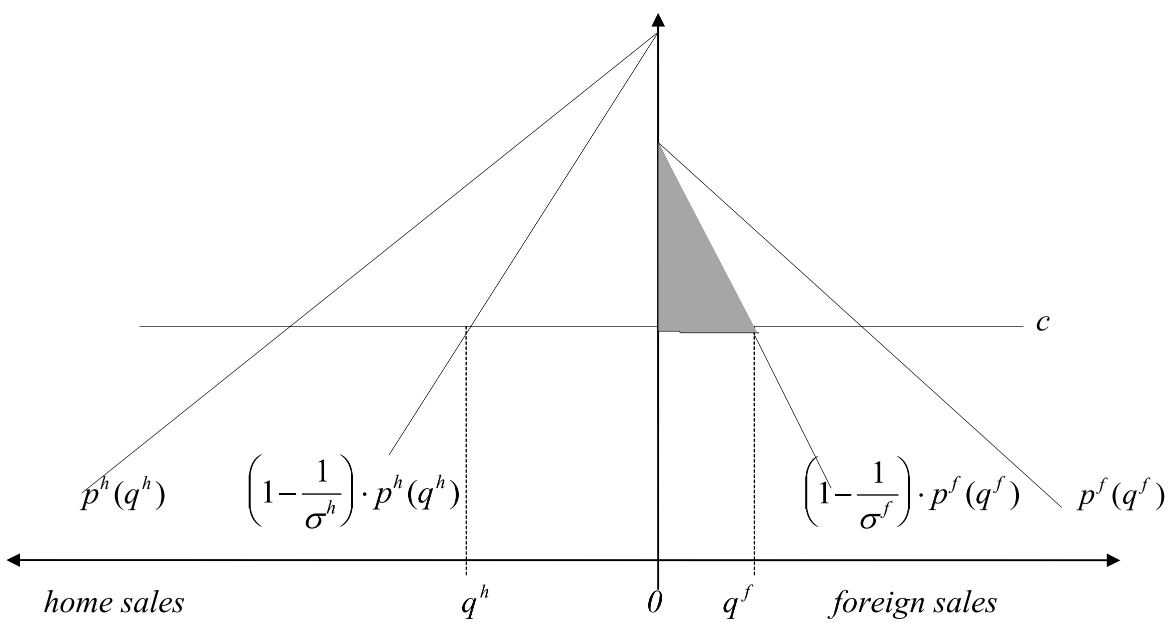
It is also commonly argued that the presence of exporters generates positive externalities for domestically oriented producers.

The literature on technology diffusion stresses mobility of labor across firms, technology transfer through local suppliers, and demonstration effects (e.g., Evanson and Westphal, 1995; Steward and Ghani, 1992).

Econometric studies establish that exporting plants in developing countries are relatively efficient

But this could reflect either learning-by-exporting or self-selection of efficient producers into export markets:

Figure I:
Gross Operating Profits from Exporting



This paper attempts to go beyond descriptive anecdotes and patterns of contemporaneous correlation. The approach is based on a simple idea. If exporting generates efficiency gains, firms that begin exporting should thereafter exhibit a change in the stochastic process that governs their productivity growth.

<u>Behavior:</u>
Let c_t = marginal cost, $\ln(c_t)$ follow a bounded first-order Markov process *conditioned* on exporting status

Let z_t = demand shifter, $q_t^f = z_t(p_t^f)^{-\eta}$, $\ln(z_t)$ also a bounded first-order Markov process.

Firms choose export market participation patterns to maximize profit stream:

$$V_t = \max_{y_t} \left[y_t\left(\pi(c_t, z_t) - (1 - y_{t-1})F\right) + \delta E_t(V_{t+1} \mid y_t) \right]$$

Using this characterization of behavior and some made-up parameters, it is possible to simulate trajectories for the average costs of different kinds of firms:

Figure IIa:
Simulated Average Cost Trajectories Without Learning

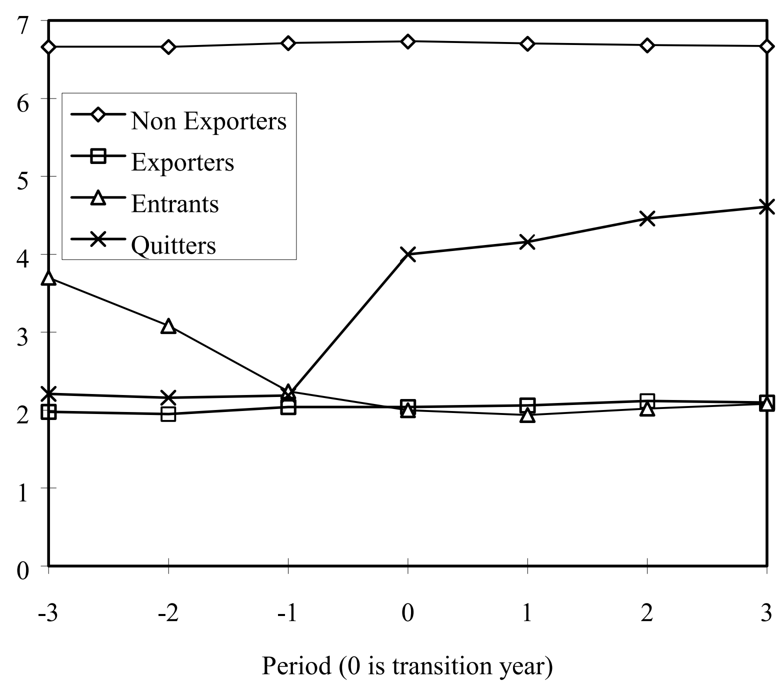
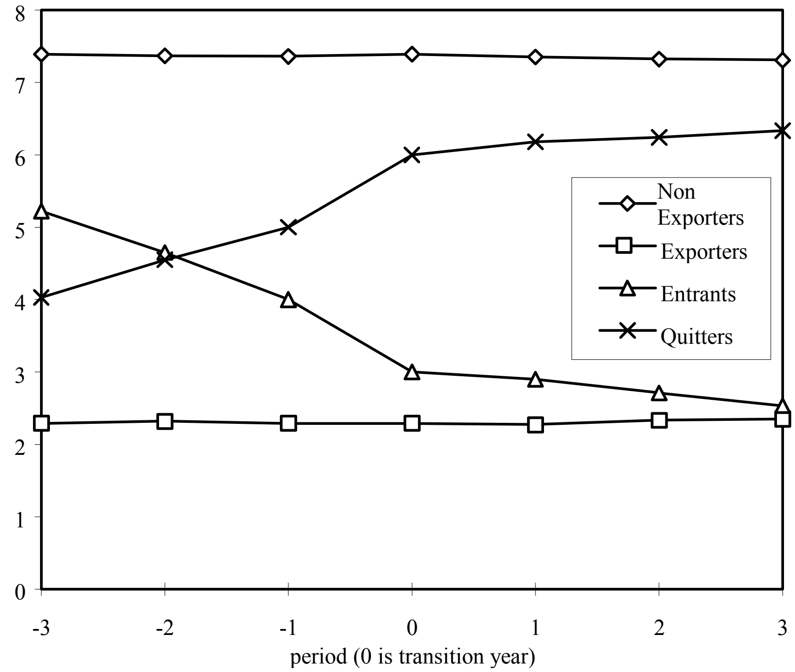


Figure IIb:
Simulated Average Cost Trajectories with Learning



<u>Implications of simulations</u>*:*

- <u>Self-selection</u>**:** Costs among the entrant group are lower than costs among the quitter group, and costs among exporters are lower than costs among non-exporters.

- New exporters get better prior to becoming exporters (all regimes), and even *with* learning, <u>rates of improvement may slow upon entry</u>*:* studies based on changes in productivity growth may be biased against finding a positive effect.

- <u>Learning effects make firms enter (and stay in) at higher costs.</u> Productivity dispersion may thus be higher among exporters when learning effects are present, and the productivity gap between exporters and non-exporters may be smaller.

- <u>With learning, the expected cost trajectory continues downward after becoming an exporter.</u>

Now let's turn to the actual data.

Following firms through time, do they become more efficient after they begin to export, or do their efficiency gains precede the exports?

$$\ln(Q/L)_{it} = \sum_{j=1}^{J}\sum_{t=1}^{T}\gamma_{jt}D_{ijt} + \beta_1 \ln(A_{it}) + \beta_2 \ln(A_{it})^2 + \beta_3 \ln(K)_{it} + \beta_3 \ln(K)_{it}^{\ 2} + \varepsilon_{it}$$

$$\ln(AVC)_{it} = \sum_{j=1}^{J}\sum_{t=1}^{T}\gamma_{jt}D_{ijt} + \beta_1 \ln(A_{it}) + \beta_2 \ln(A_{it})^2 + \beta_3 \ln(K)_{it} + \beta_3 \ln(K)_{it}^{\ 2} + \varepsilon_{it}$$

Look at residuals—pre- versus post-entry or pre- versus post-exit.

Figure IVb:
MEXICO -- Path of Average Labor Productivity (purged of time and size effects)

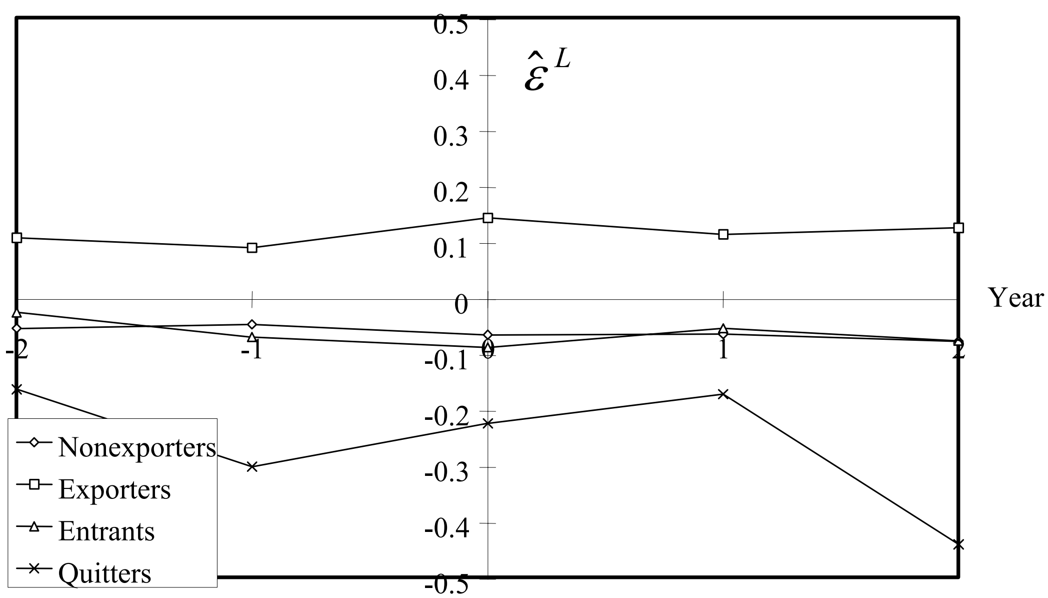


Figure IVc:
MOROCCO -- Path of Average Labor Productivity (purged of time, size, and age effects)

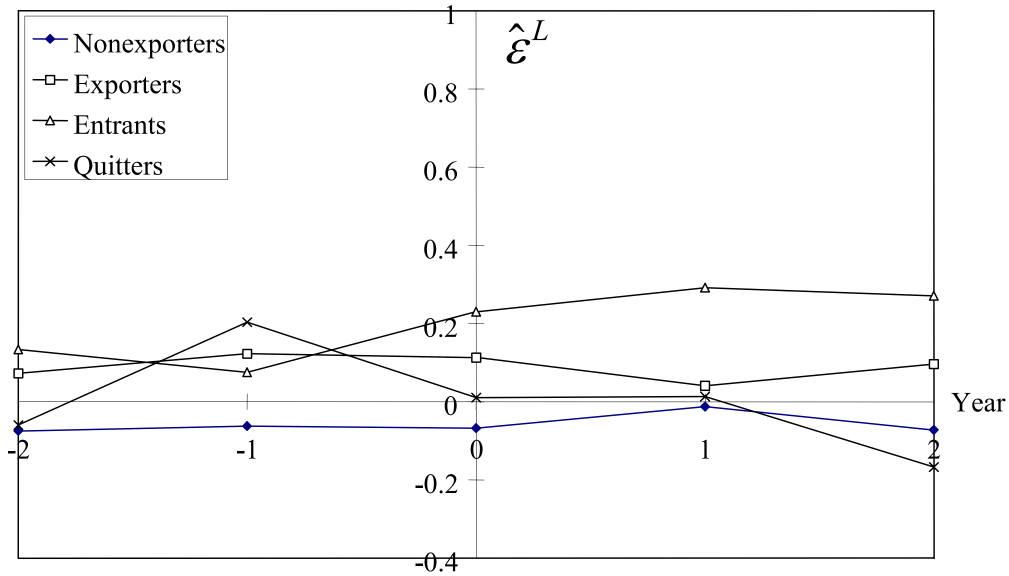
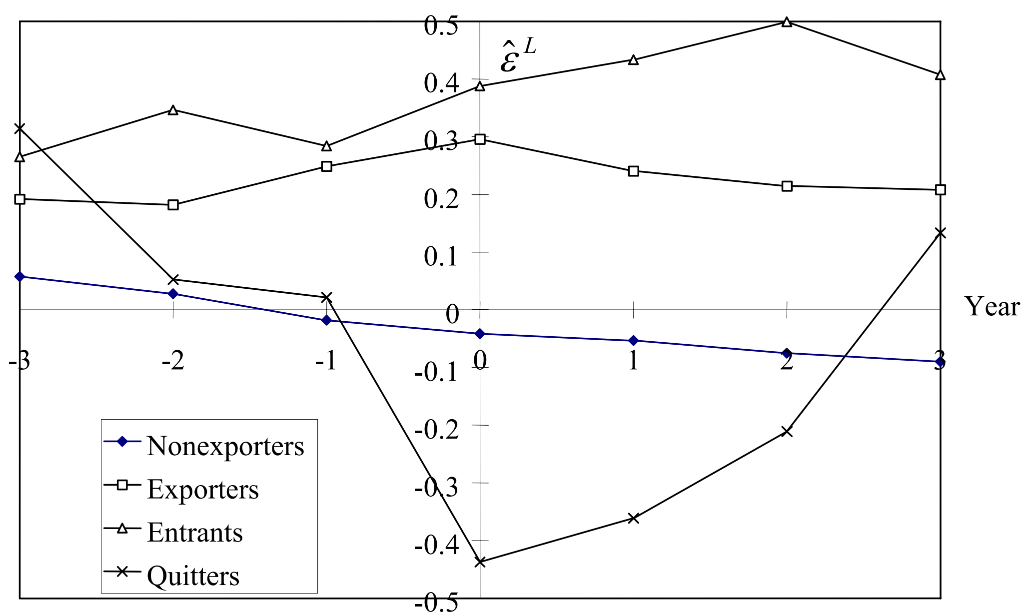


Figure IVa:
COLOMBIA -- Path of Average Labor Productivity (purged of time, age, and size effects)



The simulated framework is restrictive because the cost process may be higher order, it may depend upon relatively distant lags in exporting, and marginal costs may depend upon output. For econometric modeling, we thus use more lags:

$$\ln(AVC)_{it} = \gamma_0 + \sum_{t=1}^{T} \gamma_{jt} D_{ijt} + \sum_{j=1}^{J} \beta_1^k \ln(K_{it-j}) + \sum_{j=1}^{J} \beta_2 \left[\ln(q_{it+1-j}^d) + \ln(q_{it+1-j}^f)\right]$$
$$+ \sum_{j=1}^{J} \beta_3^j \ln(AVC_{it-j}) + \sum_{j=1}^{J} \beta_4^j y_{it-j} + \alpha_i + \varepsilon_{it}$$

We view the disturbance as potentially serially correlated, and thus potentially correlated with exporting history and with output history.

Current output is considered endogenous.

Note: The distributed lag in previous average variable cost realizations controls for unobserved plant-specific factor prices, so long as these follow an AR(J) process.

Colombia (Table IVa):

- ***Equation works best in levels*** (no evidence of serial correlation)
- ***No evidence of a negative association between exporting history, however measured, and average variable costs.***
    - ***Output levels matter***; usually a contemporaneous negative correlation

Morocco (Table IVb):

- Like Colombia, ***equation works best in levels***.
- No evidence of negative association for industries treated in *FIML* tables, but ***apparel and leather show significant negative association.*** (Learning, multinationals, or duty drawbacks?)
- ***Output levels don't matter in this country***—average variable cost functions look flat.

GMM Estimates of Cost Function, Colombia, 1986-1991

	Apparel	Other Chemicals	Textiles	Paper
Coefficient on:				
y_{it-1}	0.029 (0.0213)	-0.012 (0.013)	0.018 (0.019)	-0.021 (0.019)
y_{it-2}	0.001 (0.032)	0.015 (0.021)	0.011 (0.047)	-0.013 (0.021)
y_{it-3}	0.044 (0.031)	0.000 (0.023)	-0.014 (0.021)	0.030 (0.021)
Wald test, joint signif., $\chi^2(3)$	15.00*	1.47	2.13	2.51
Sargan test, instr., $\chi^2(23)$	10.02	29.52	19.74	26.51
1st order autocorr., $N(0,1)$	0.02	0.17	-0.45	-0.00
2nd order autocorr., $N(0,1)$	0.74	-0.10	0.20	-0.84
No. plants	283	169	206	69
No. observations	1698	1014	1236	414

	Industrial Chemicals	Non-Beverage Food Processing	Beverages
Coefficient on:			
y_{it-1}	-0.036 (0.021)	-0.001 (0.014)	-0.073 (0.030)
y_{it-2}	0.006 (0.025)	0.010 (0.013)	0.073 (0.049)
y_{it-3}	0.029 (0.016)	-0.005 (0.010)	0.014 (0.034)
Wald test, joint signif., $\chi^2(3)$	9.72*	1.04	11.49*
Sargan test, instr., $\chi^2(23)$	23.72	26.87	17.49
1st order autocorr., $N(0,1)$	-0.93	-1.03	-0.47
2nd order autocorr., $N(0,1)$	-1.16	-0.06	0.66
No. plants	63	301	93
No. observations	378	1806	558

Standard errors in parentheses; a star indicates that the estimate is significant at a 95 percent significance level.

The regressions include the following variables: 3 lags of cost, 3 lags of capital stock, current output plus 3 lags, business type, age, age squared, time dummies.

All are included in the instrument set except current output, which is instrumented with functions of its lagged value

Related studies

Some studies of developed countries have found qualitatively similar patterns:

Bernard and Jensen (*Review of Economics and Statistics*, 2004) on the United States

Others, focusing on developing countries, have identified cases of possible learning effects:

Aw, Chung and Roberts (2000, *World Bank Economic Review*) on South Korea and Taiwan

China (Kraay, 1999, *Revue d'Economie du Dévelopement*) on China

Van Biesebroeck (2004, unpublished) on Sub-Saharan Africa

But these studies could not use the detailed annual data. If lags are truncated, exporting history can proxy for more distant cost shocks.

Final comment

This literature suffers from the usual disconnect between the performance measures and the thing we really care about—firms' contributions to social welfare.

III. PULLING SOME PIECES TOGETHER (ERKAN AND TYBOUT, 2004)

We've seen that

- Openness is often followed by "productivity" improvements, and that these improvements come from two sources: market share reallocations and intra-firm efficiency gains.

- We've also seen that it makes sense to think of innovation as reflecting conscious investments, and that spillovers matter too.

- Finally, we've argued that productivity isn't the appropriate metric for performance when products are differentiated. One focus on welfare, which reflects losses in varieties if domestic firms exit, capital losses imposed on surviving firms, and employment turnover generated in the transition.

To do all this in an integrated model, and to fit the model to actual data, is beyond the current scope of the literature. But by using invented parameter values, one can get a sense for how these aspects of response to opening fit together in a dynamic optimizing framework with uncertainty. And the models parameters can be chosen in such a way that it roughly replicates the econometric findings we've seen thus far.

The analysis is based on work by Pakes and Ericson (1995) and Pakes and McGuire (1994). Let's begin by reviewing the structure of their models.

Features of PEM:

- Partial equilibrium: differentiated product industry.

- Entrepreneurs create new firms when the expected discounted net earnings stream exceeds entry costs;

- Entrepreneurs sell their firms for scrap when the expected discounted net earnings stream is less than scrap value.

- Active firms Bertrand compete in the product market each period (logit demand functions). Price choices don't affect future states.

- Active firms can invest in R&D each period. The larger the investment, the higher the probability of a product improvement. (Strategies are Markov-perfect Nash.)

- The outside good improves with constant exogenous probability.

- The quality of entrants' goods is drawn from a distribution that improves at the rate of improvement in outside goods.

The Pakes/McGuire structure

Let the vector s summarize the industry state. The j^{th} element of the vector s indicate the number of active firms at quality level j. For example $s = \{0, 0, 1, 4, 3, 0\}$ means there is one firm with quality level 3, there are four firms with quality level 4 and there are 3 firms with quality level 5.

An active firm with product quality level i earns current period profits $\pi(i_t, s_t)$, which reflect pure Bertrand price competition in the spot market and logit demand functions with vertically *and* horizontally differentiated goods.

Its value function satisfies:

$$V(i,s) = \max\left\{\phi,\ \pi(i,s) + \sup_{x \geq 0}\left[-cx + \beta \sum_{i',s'} V(i',s')p(i',s' \mid x,i,s)\right]\right\}$$

$p(i',s'\|i,s)$	perceived transition probability distribution
ϕ	firm's scrap value
x	firm's investment level
c	unit cost of investment.

New firms pay a stochastic sunk start-up cost, x_e, and begin with initial quality i_e relative to the imported good.

They enter when their expected value $V(i_e, s)$ is positive. (New firms earn zero profits during their first period of operation.)

Firms spend x_t to achieve a unit increment to their quality (relative to the imported good) with probability $\frac{ax_t}{ax_t + 1}$.

Equilibrium obtains when beliefs are consistent with actual behavior.

Our modifications to the Pakes/McGuire framework:

Replace the outside good with an imported variety with exogenous price, P_0, to compete with the domestic varieties. Use nested logit demand system.

•The quality of the imported variety improves each period with probability, δ.

•The distribution of initial product qualities improves with the quality of imported goods (embodied tech. change).

The j^{th} consumer derives the following utility from consuming a unit of product i in period t :

$$U_{ijt} = \begin{cases} \omega_{0t} + \omega_{it} - \theta P_{it} + \xi_{j,1t} + (1-\varphi)\varepsilon_{ijt} & i = 1, N_t \\ \omega_{0t} - \theta P_{0t} + \xi_{j,0t} + (1-\varphi)\varepsilon_{0jt} & i = 0 \end{cases}$$

Here $\omega_{it} = f(i_t)$ is excess mean utility derived from goods of quality *i*, beyond that obtained from the imported good. $f'(\cdot) \geq 0$, $f''(\cdot) < 0$. Note that after *t* periods, $\omega_{0t} = g\left(\sum_{k=1}^{t} \zeta_k\right)$ is mean utility derived from the imported good.

The model allows for:

- –Schumpeterian effects
- –"Escape competition" effects
- –Market share and entry/exit (rationalization) effects
- –Embodied technological change

It does not allow for agency/shirking effects

The policy experiments

•Reduced Price of Imports, ↓ P_0 (RPM).

- –Commercial policy reforms
- –One-time appreciation

•Accelerated rate of innovation for imported goods, ↑ δ (AIM)

- –Allow a different class of goods into the country;
- –Trade with a different kind of partner.

Simulation details

- For both experiments, simulate 100 trajectories of 5,000 periods each and average.
- Start from negligible import penetration.
- Typically, 25 percent of the firms turn over in one period, so think of one period as 2-3 years.
- All firms have the same marginal cost, but think of improvements in quality as similar to idiosyncratic reductions in marginal cost. (Both increase profits.)

Parameters	*Reduced Price for Imports (RPM)*	*Accelerated Innovation for Imports (AIM)*
Marginal costs of production (domestic firms)	1	1
Market Size (M)	10	10
Discount factor (β)	0.925	0.925
Scrap Value (ϕ)	0.1	0.1
Max Efficiency ($i^{\max}$)	21	21
Investment efficiency (a)	2	2
Price sensitivity of consumers (θ)	5	5
Degree of substitution between nests (σ)	0.5	0.5
Price of the imported good (P_0)	1.5 to 0	1.5
Probability of Innovation in the Imported good δ)	0.6	0.6 to 0.8

How important are escape competition effects?

$$\pi(i+1, s_{-i} \mid P_0 = 0) - \pi(i, s_{-i} \mid P_0 = 0)$$

versus

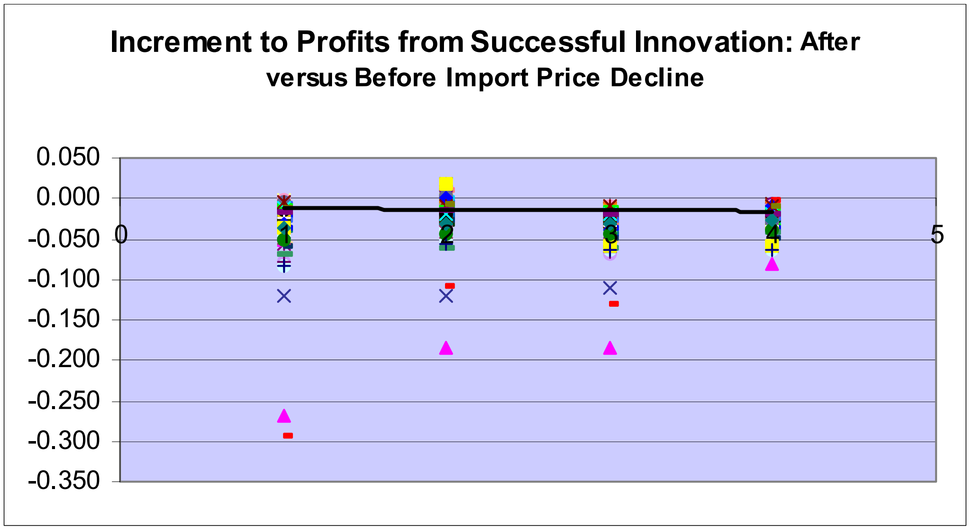
$$\pi(i+1, s_{-i} \mid P_0 = 1.5) - \pi(i, s_{-i} \mid P_0 = 1.5)$$

$$\pi(i+1, s_{-i} \mid \xi_t = 1) - \pi(i, s_{-i} \mid \xi_t = 1)$$

versus

$$\pi(i+1, s_{-i} \mid \xi_t = 0) - \pi(i, s_{-i} \mid \xi_t = 0)$$

Calculate differences for 100 most common states in base case, 4 best firms.


Increment to Profits from Successful Innovation: After versus Before Import Price Decline
0.050
0.000
-0.050
-0.100
-0.150
-0.200
-0.250
-0.300
-0.350
0
1
2
3
4
5

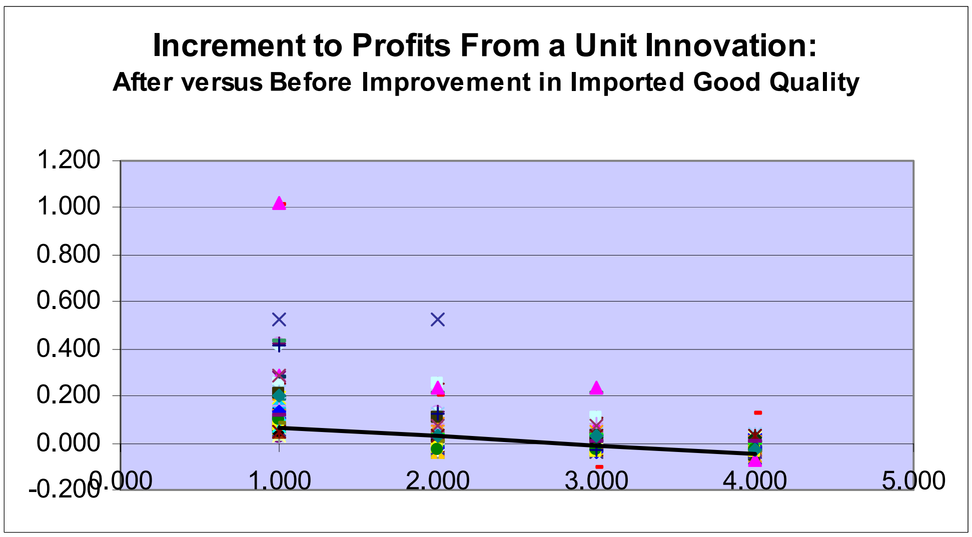

Increment to Profits From a Unit Innovation: After versus Before Improvement in Imported Good Quality
1.200
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
0.000
1.000
2.000
3.000
4.000
5.000

Table 3: Summary Statistics for RPM and AIM regimes*

	Base case	*Reduced Price for Imports (RPM)*	*Accelerated Import Innovation (AIM)*
	$P_0 = 1.5$, $\delta = 0.6$	$P_0 = 0.0$, $\delta = 0.6$	$P_0 = 1.5$ $\delta = 0.8$
Percentage of periods with entry and exit*	55.8	57.8	72.1
Mean number of firms active*	3.8	3.6	2.9
Mean lifespan*	5.3	5.0	4.2
Mean consumer surplus**	855.3	1045.9	686.5***
Mean producer surplus**	27.9	25.0	30.1
Mean total surplus**	882.8	1072.0	716.6***

* Means taken across 100 trajectories of 5,000 periods each

* Means taken across 100 trajectories of 100 periods each, discounted back to initial year of regime

***Excludes gains due to more rapid growth in the average quality of goods.

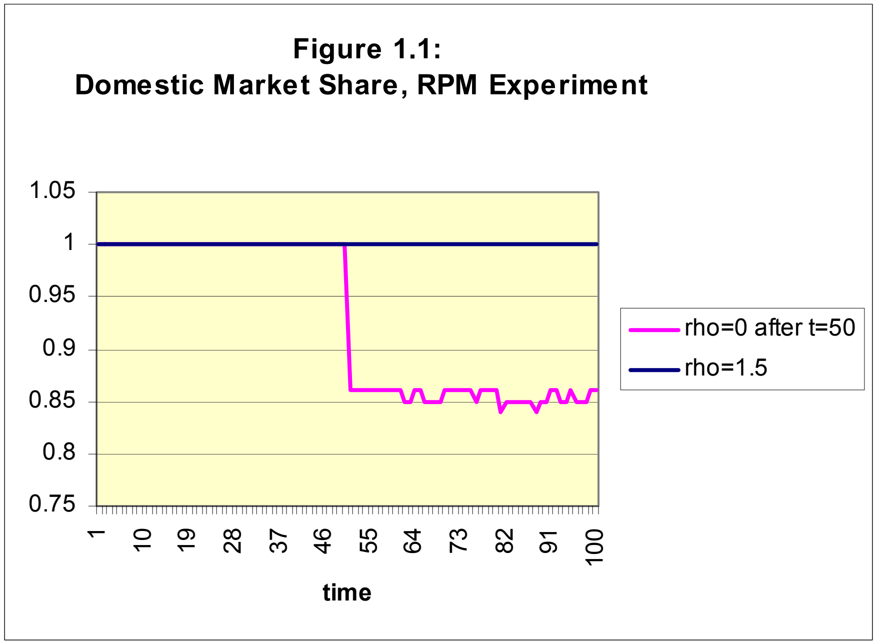


Figure 1.1:
Domestic Market Share, RPM Experiment
1.05
1
0.95
0.9
0.85
0.8
0.75
1
10
19
28
37
46
55
64
73
82
91
100
time
rho=0 after t=50
rho=1.5

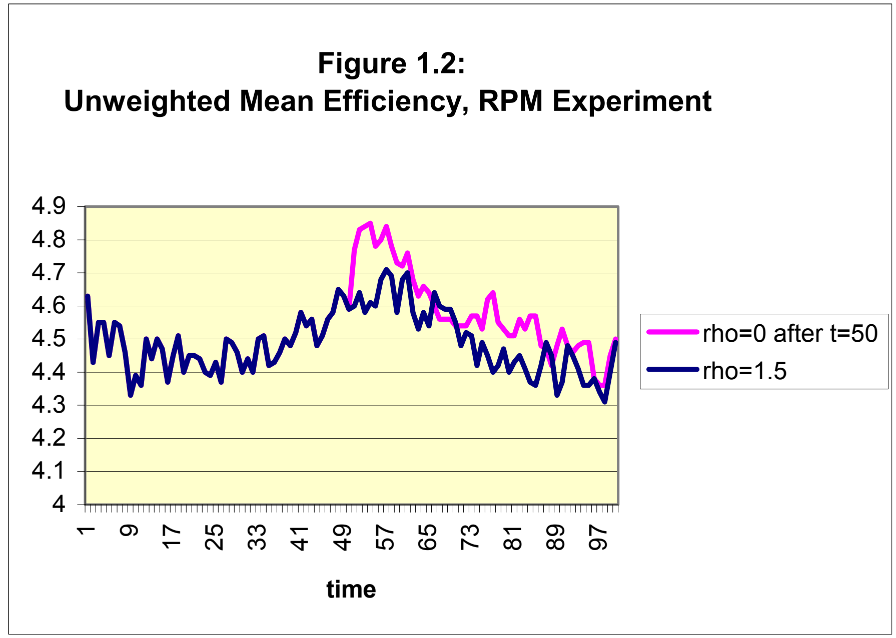


Figure 1.2:
Unweighted Mean Efficiency, RPM Experiment
4.9
4.8
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4
1
9
17
25
33
41
49
57
65
73
81
89
97
time
rho=0 after t=50
rho=1.5

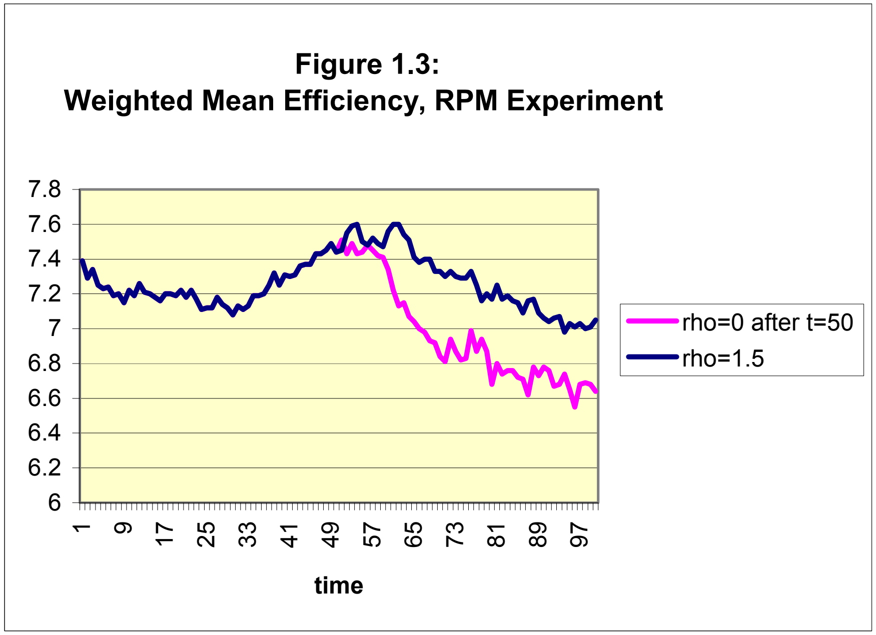


Figure 1.3:
Weighted Mean Efficiency, RPM Experiment
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
6
1
9
17
25
33
41
49
57
65
73
81
89
97
time
rho=0 after t=50
rho=1.5

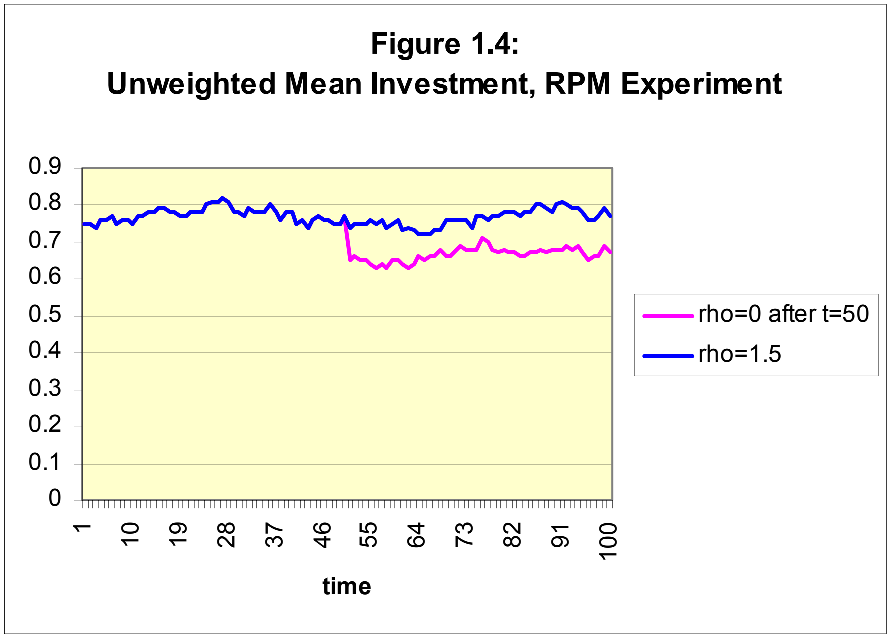


Figure 1.4:
Unweighted Mean Investment, RPM Experiment
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
10
19
28
37
46
55
64
73
82
91
100
time
rho=0 after t=50
rho=1.5

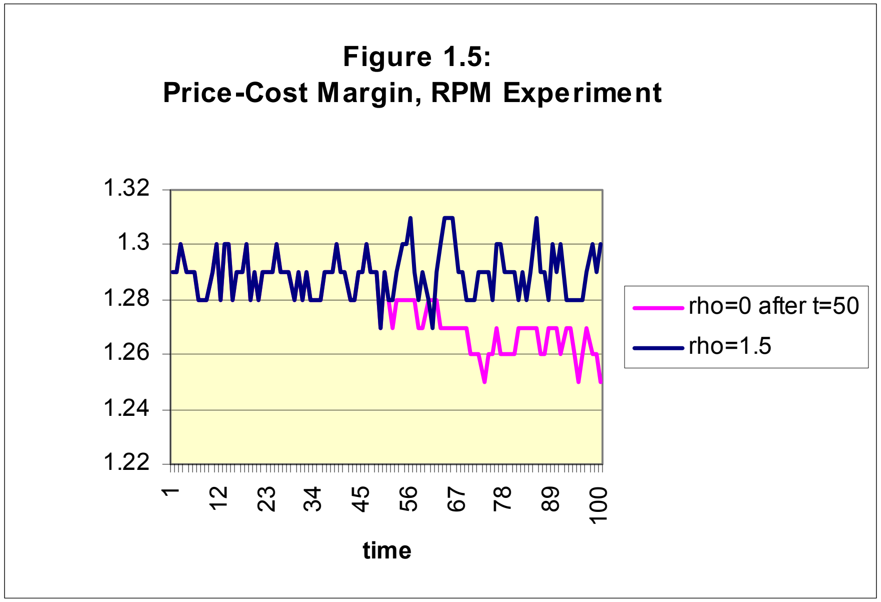


Figure 1.5:
Price-Cost Margin, RPM Experiment
1.32
1.3
1.28
1.26
1.24
1.22
1
12
23
34
45
56
67
78
89
100
time
rho=0 after t=50
rho=1.5

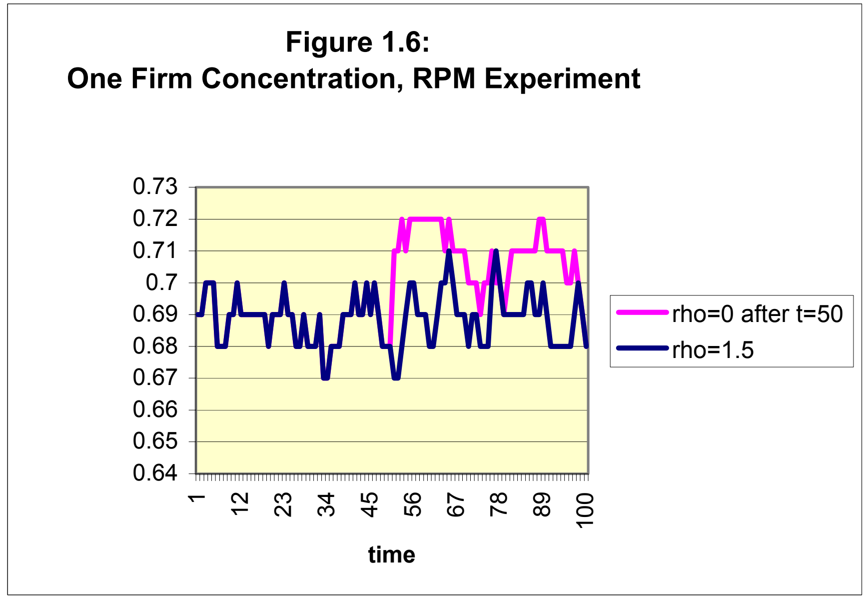


Figure 1.6:
One Firm Concentration, RPM Experiment
0.73
0.72
0.71
0.7
0.69
0.68
0.67
0.66
0.65
0.64
1
12
23
34
45
56
67
78
89
100
time
rho=0 after t=50
rho=1.5

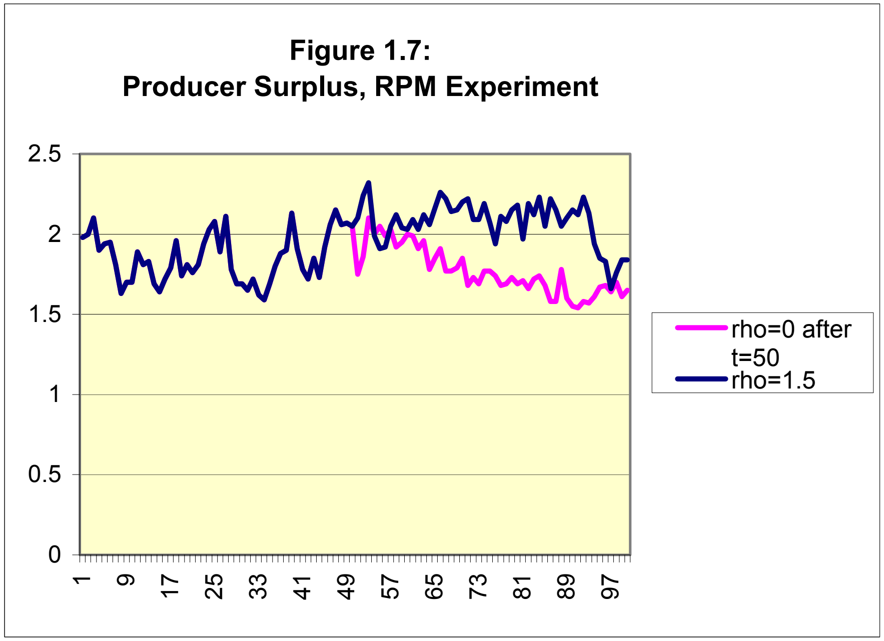


Figure 1.7:
Producer Surplus, RPM Experiment
2.5
2
1.5
1
0.5
0
1
9
17
25
33
41
49
57
65
73
81
89
97
rho=0 after t=50
rho=1.5

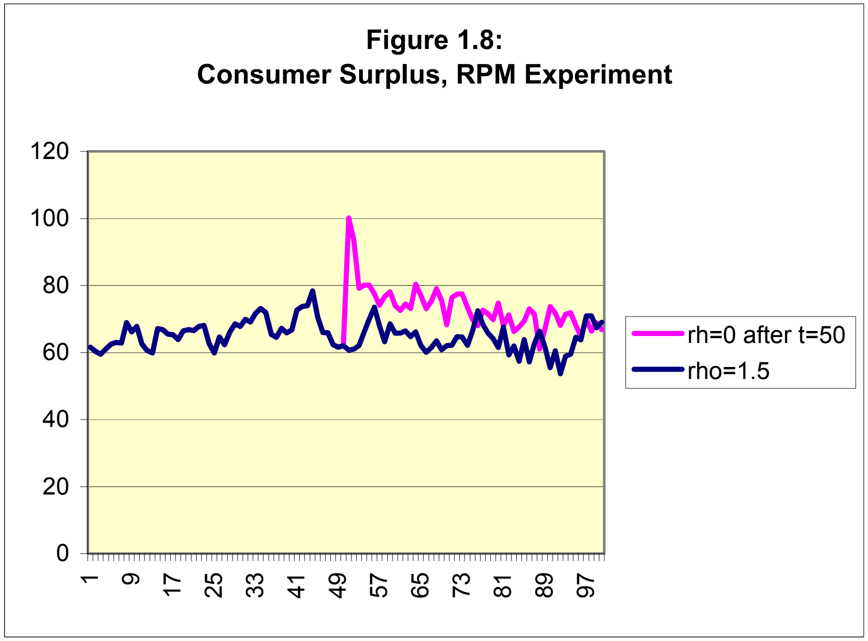


Figure 1.8:
Consumer Surplus, RPM Experiment
120
100
80
60
40
20
0
1
9
17
25
33
41
49
57
65
73
81
89
97
rh=0 after t=50
rho=1.5

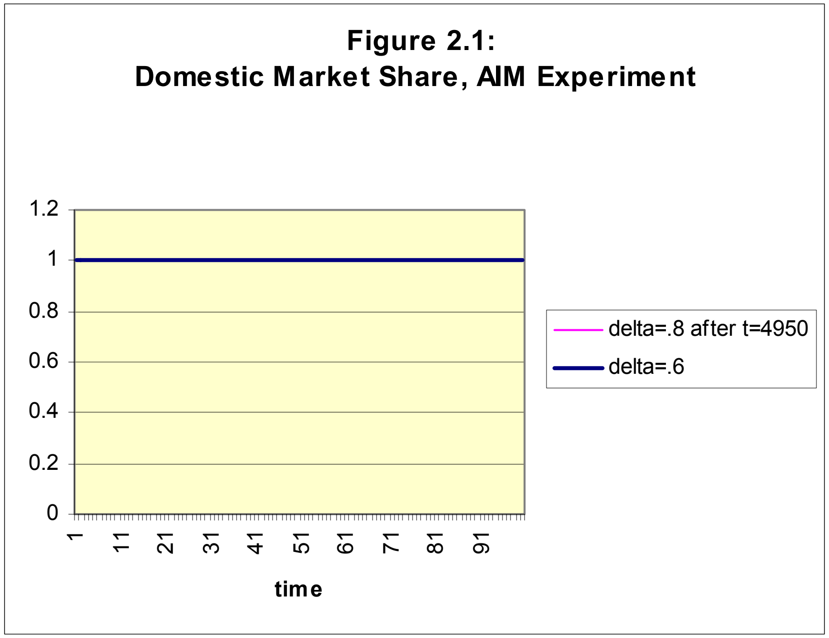


Figure 2.1:
Domestic Market Share, AIM Experiment
1.2
1
0.8
0.6
0.4
0.2
0
1
11
21
31
41
51
61
71
81
91
time
delta=.8 after t=4950
delta=.6

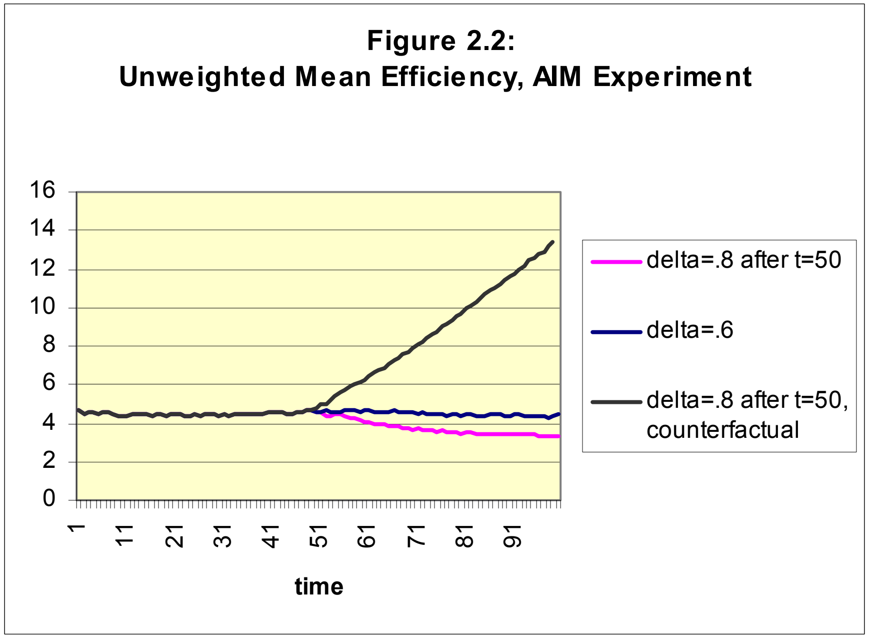


Figure 2.2:
Unweighted Mean Efficiency, AIM Experiment
16
14
12
10
8
6
4
2
0
1
11
21
31
41
51
61
71
81
91
time
delta=.8 after t=50
delta=.6
delta=.8 after t=50, counterfactual

Figure 2.3:
Weighted Mean Efficiency, AIM Experiment

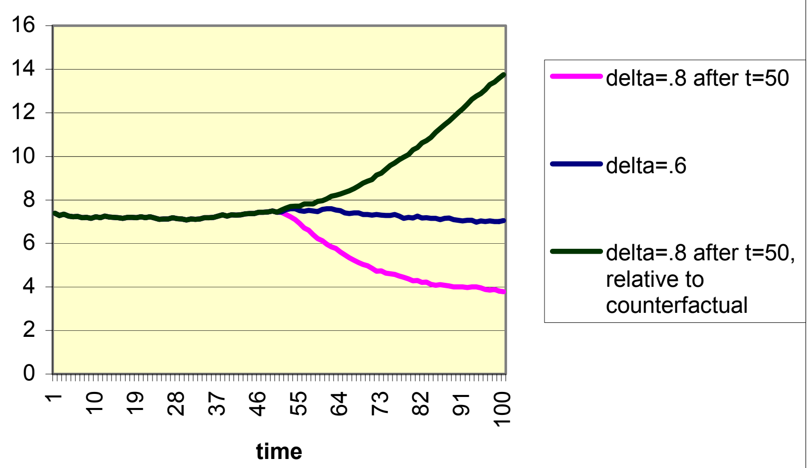
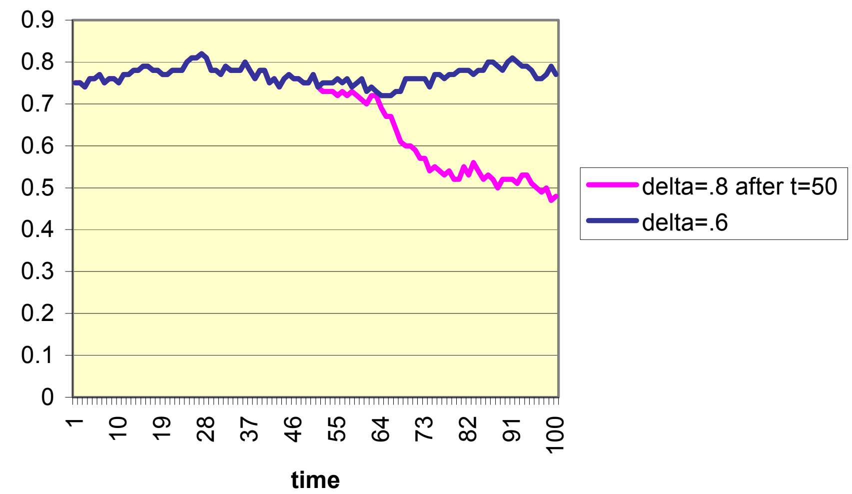


Figure 2.4:
Unweighted Mean Investment, AIM Experiment



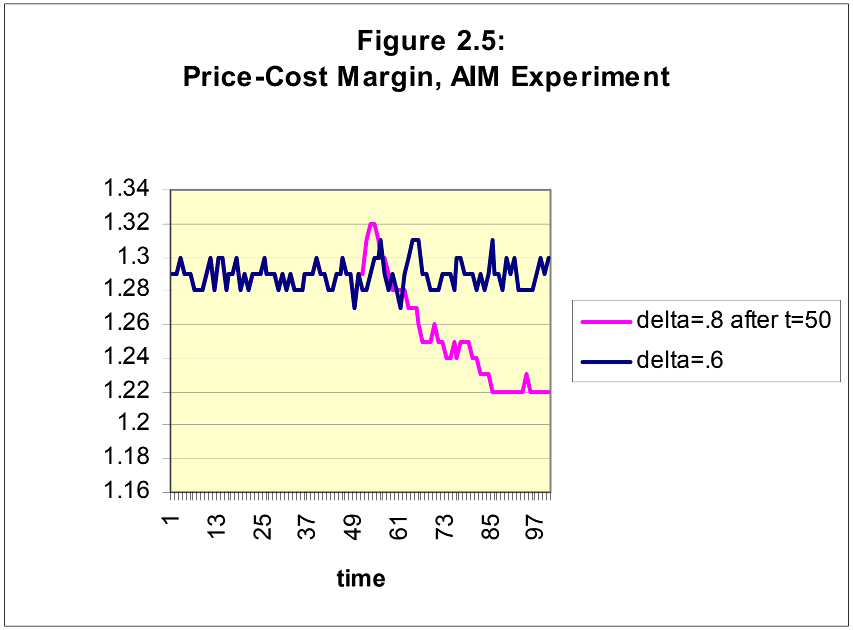


Figure 2.5:
Price-Cost Margin, AIM Experiment
1.34
1.32
1.3
1.28
1.26
1.24
1.22
1.2
1.18
1.16
1
13
25
37
49
61
73
85
97
time
delta=.8 after t=50
delta=.6

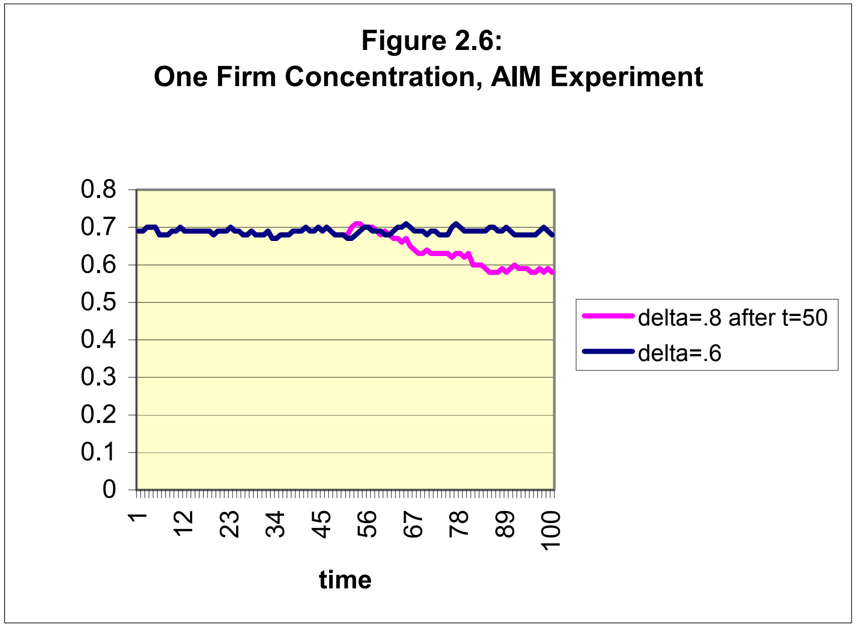


Figure 2.6:
One Firm Concentration, AIM Experiment
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
12
23
34
45
56
67
78
89
100
time
delta=.8 after t=50
delta=.6

Figure 2.7:
Producer Surplus, AIM Experiment

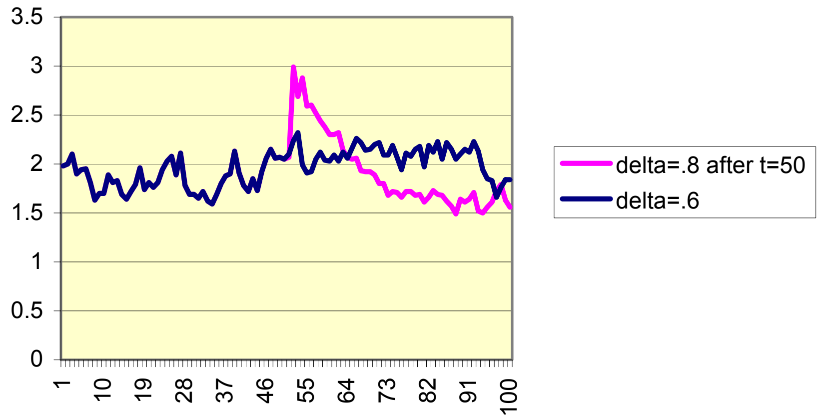
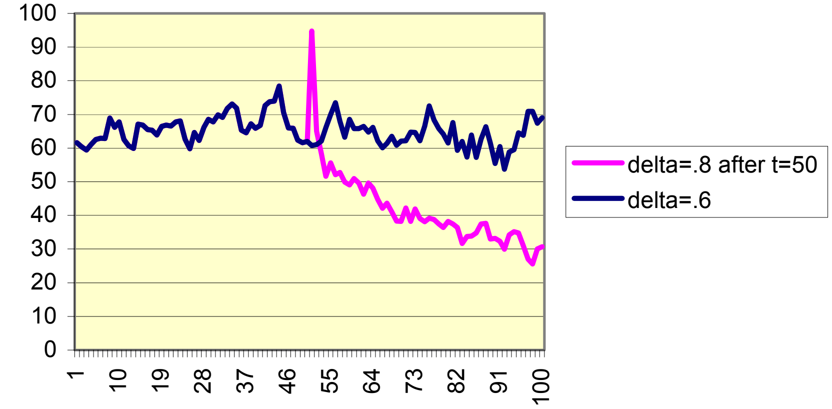


Figure 2.8:
Consumer Surplus, AIM Experiment



Summary of reduced price of imports case

- A reduction in the price of the imported variety reduces market shares, margins and profits for domestic firms. All this is consistent with the econometric evidence. It implies rationalization (also consistent with the econometric evidence) and capital losses.

- The heightened import competition also discourages investment and gradually causes a deterioration in the relative appeal/efficiency of domestic producers. These longer run, less desirable effects of openness are not documented econometrically, but that doesn't mean they don't exist. We haven't had natural experiments over long enough time horizons to observe them.

- When they are investing less, firms don't live as long—more rapid turnover in job.

- Producers are worse off and consumers are better off, although the gains in consumer welfare are concentrated early in the reform.

- This set of results describes an import-competing industry. The story would basically be flipped for an export-oriented industry: Initial decline in efficiency because marginal firms are able to survive as the relative demand for their sector's goods increases. Over the longer term, Schumpeterian effects *encourage* investment.

Summary of accelerated innovation of imports case

- There is no immediate deterioration in market share because it takes time for the more rapid innovation abroad to build up a gap in quality. However, here too there is an incentive to back off investing.

- Margins decline as the relative appeal of the domestic products drops.

- Entering firms find it worthwhile to enter because they are initial at global best practice. But they don't find it optimal to invest enough to keep up. Thus turnover increases among the domestic firms.

Because the gap between domestic and foreign quality/efficiency eventually stabilizes, and because foreign quality/efficiency is growing relatively rapidly, domestic producers show more rapid improvement in absolute terms.