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Comment Jeffrey R. Campbell

Technology introduction takes place firm-by-firm and establishment-by-establishment. Even a good idea that falls from the sky (the classic neutral technology shock) must be read and incorporated into a production plan. For this reason, the analysis of individual producers' birth, growth, and death occupies a central place in productivity analysis. The Longitudinal Research Database provided the first observations of this process for the United States' Manufacturing sector, and its analysis by Dunne, Roberts, and Samuelson (1988), Bartelsman and Dhrymes (1998), and others created a new appreciation of creative destruction's contribution to productivity growth. Of course, these empirical developments would have been impossible without the contributions of Jovanovic (1982) and Hopenhayn (1992) to the theory of industry dynamics.

Manufacturing led U.S. economic growth through the 1960s, but Retail Trade and Services have worn the yellow jersey since then. Further progress relating productivity growth to industry dynamics therefore requires our empirical and theoretical work to catch up to this new leading sector. Jarmin, Klimek, and Miranda have given us a substantial push in this direction. Although they are not the first to examine producer-level data from Retail Trade, they are the first (to my knowledge) to do so in light of that sector's central economic fact: the replacement of stand-alone mom-and-pop stores by large chain stores with low prices. Today, Wal-Mart's rise occupies the headlines, but regional and nation chain growth inspired the anti-chain-store movement of the 1920s and 1930s. The specific players and their tactics have changed, but the issues at hand remain the same: do

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new low-cost retailers improve welfare by lowering prices or retard it by lowering wages and displacing other competitors?

Previous work on the Manufacturing sector has left us ill prepared for these questions, because the dominant approach to that sector presumed some form of atomistic competition (either the price-taking perfect variety or the price-setting monopolistic variety) in which strategic interactions are absent. Evidence in Campbell and Hopenhayn (2005), Campbell (2006), and Yeap (2005) shows that atomistic competition cannot even rationalize basic features of the data like the dependence of establishment size, prices, and turnover on market size. The first step in understanding industry dynamics and productivity growth in the retail and service sectors is to confront the strategic aspects of their market interactions. Jarmin, Klimek, and Miranda contribute to this by delineating the important players in any retail market and by reporting useful stylized facts about trend rates of displacement and turnover. In this discussion, I wish to complement their contribution with a relatively simple model of dynamic retail competition with both chain stores and independents.

Retail has great potential for strategic complexity. Firms operate several distinct technologies and differentiate themselves geographically. It is not difficult to specify a model that embodies all of these features. However, such a model's complexity precludes its analytic characterization. There might be one equilibrium or many, and they do not lend themselves to local comparative statics results like those Hopenhayn (1992) develops for a competitive industry. With this in mind, the model I develop vastly simplifies the spatial aspects of competition so that we can learn something about competition between dominant chain producers and a fringe of high-cost independent producers.

A Model

To build a model with nontrivial dynamics and strategic interaction, I draw on my previous work with Jaap Abbring (Abbring and Campbell 2006). We develop a model of Markov-perfect duopoly dynamics with stochastic demand, sunk costs of entry, and irreversible exit. Firms make their continuation decisions oldest first, and we focus on the unique equilibrium in which firms' exits follow a last-in first-out pattern. In this discussion, I construct a symmetric equilibrium in a similar model with a fringe of monopolistically-competitive independent producers.

Primitives

Consider a region with a central city and a large number L of outlying villages. The city's name is 0, and the villages names are $j = 1, \ldots, L$. The villages are arranged in a circle with the city at its center. A single road connects each village to the city. We denote the population of location j in year t with C^j_t. These follow independent (across locations) Markov chains. With probability λ, $C^j_t = C^j_{t-1}$. With the complementary probability, C^j_t is a draw from a uniform distribution on $[\hat{C}_v/L, \check{C}_v/L]$ for a village and $[\hat{C}_c, \check{C}_c]$ for the city.

Consumers have identical incomes measured in money (y) and they allocate their purchases across an outside good available everywhere at a price of 1 and the good of interest. This latter good is not necessarily available at the same price everywhere. If a consumer purchases q units of this good at a price of p in her home location, then her utility level is

$$\int_0^q D^{-1}(x)dx + y - pq.$$

If she has to travel to make the same purchase, she must pay a transportation cost T (in units of money). For simplicity, assume that a villager may only travel to the city and ignore the possibility of a city dweller shopping in a village. Consumers' travel costs are random. The *c.d.f* $\tau(x) = \Pr[T \leq x]$ governs their distribution

There are two production technologies. One has higher fixed costs and lower variable costs than the other. I refer to these as the *big-box* and *independent* technologies. Each village has one potential entrant per period. This firm must choose between entering at that location with the independent technology or remaining out of the market. This opportunity always goes to a new firm, so the decision to remain inactive is irreversible. The city has two potential entrants each period, and each of them has access to only one of the technologies. As with the villages' potential entrants, they cannot delay their entry decisions.

The sunk cost of entering with the big-box technology is φ_b. Producing with this technology in any period after entry requires paying the fixed cost κ_b. The only way of avoiding this fixed cost is to exit irreversibly. This technology's constant marginal cost of production is ω_b. Entering with the independent technology requires no sunk cost and a per-period fixed cost of $\kappa_i < \kappa_b$. A higher marginal cost $\omega_i > \omega_b$ and a shorter life span offset these advantages. A firm entering with the independent technology can produce for only one period. Relaxing this extreme assumption in future versions of this model is clearly desirable.

Firms with the big-box technology discount future profits with the constant discount factor $\beta < 1$. The model has two physical state variables, the number of firms which produced in the city in the previous period, N^0_t, and the vector of market populations $\vec{C}_t \equiv (C^0_t, C^1_t, \ldots, C^L_t)$. Each period, the sequence of actions proceeds as follows.

1. All potential entrants and incumbent firms (in the city) observe the realization of $\vec{C}_t$.
2. Any incumbent firms make their continuation decisions simultaneously.

3. The city's big-box potential entrant decides whether or not to enter.
4. The city's independent potential entrant decides whether or not to enter.
5. The villages' potential entrants make their entry decisions simultaneously.
6. With observations of their travel costs and all firms' entry and continuation decisions, consumers select their shopping locations.
7. After the consumers arrive at their shopping locations, firms simultaneously choose quantities. An auctioneer then sets prices to clear the locations' markets.

Equilibrium

With the model's primitives in place, we seek a Markov-perfect equilibrium. We first characterize the static parts of the model, which correspond to stages 5 through 7 in the previous list. With these solved, I build on results from Abbring and Campbell (2006) to characterize the dynamics of the big-box sector. To simplify the analysis, I proceed under two assumptions: entering as the third big-box producer and entering the city as an independent with a big-box firm committed to production are dominated strategies. With the proposed equilibrium in place, finding conditions that guarantee this will be the case is not hard.

Static Play

Begin with the firms' quantity decisions. All firms' profits are linear in the number of customers shopping at their locations, so we can consider their choices of quantity per customer. By construction, at most one firm serves each village. Its producer surplus per customer is $[D^{-1}(q) - \omega_i]q$. Denote the profit-maximizing choice of q with q_i^* and the resulting per customer surplus with $\pi_i^* \equiv [D^{-1}(q_i^*) - \omega_i]q_i^*$. For a firm exclusively operating the big-box technology in the city, the choice of q is similar. The resulting per customer profit and its associated quantity are $\pi_b^*(1)$ and $q_b^*(1)$. If there are two big-box firms operating, then their quantity decisions correspond to the standard Cournot solution. Denote the per customer duopoly profit for a firm with marginal cost w facing a rival with $\pi_b^*(2)$ and the per customer duopoly quantity (summed across both firms) with $q_b^*(2)$.

The quantity choices and the resulting prices determine villagers' choices of shopping locations. A resident of a village with no producer chooses to shop in the city if her utility gain from doing so exceeds her travel cost. That is, if

$$\int_0^{q_b^*(N_t^0)} D^{-1}(x)dx - D^{-1}[q_b^*(N_t^0)]q_b^*(N_t^0) > T.$$

The last term on the left-hand side is the total purchase cost of the $q_b^*(N_t^0)$ units of the good. If we call the left-hand side of this inequality $W_c(N_t^0)$, then the fraction of such villagers choosing to shop in the city is $\tau[W_c(N_t^0)]$. For residents of villages with producers, purchasing from the local producer is the alternative to shopping in the city. The utility gain from shopping locally (compared with consuming the entire budget in the outside good) is

$$W_v(N_t^0) \equiv \int_0^{q_i^*} D^{-1}(x)dx + y - D^{-1}(q_i^*)q_i^*.$$

Clearly, the local producer's profit maximization guarantees that this is positive, so the fraction of consumers choosing to shop locally is $1 - \tau[W_c(N_t^0) - W_v(N_t^0)]$. The remaining consumers shop in the city.

Given the number of firms serving the city, a village's potential entrant rationally forecasts $W_c(N_t^0)$ and consumers' travel decisions and decides to enter only if the corresponding profit is nonnegative. That is, if

$$C_t^j\{1 - \tau[W_c(N_t^0) - W_v(N_t^0)]\}\pi_i^* - \kappa_i \geq 0.$$

Clearly, there is a threshold value of population $\overline{C}_i(N_t^0)$, which sets this profit to zero. Entry into village j is profitable if $C_t^j \geq \overline{C}_i(N_t^0)$.

Because L is large and the villages' populations are statistically independent, we can apply a law of large numbers to show that the number of villagers traveling to the city is a nonstochastic function of only N_t^0, the number of competitors in the city. In any given period, the number of residents of villages with no local producer equals $1/2\{[\overline{C}_i(N_t^0)]^2 - (\hat{C}_v)^2\}/(\check{C}_v - \hat{C}_v)$. The remaining villagers have the option of purchasing from a local producer. Putting these together, we get that the number of villagers shopping in the city equals

$$M(N_t^0) \equiv \tau[W_c(N_t^0)] \times \frac{[\overline{C}_i(N_t^0)]^2 - (\hat{C}_v)^2}{2(\check{C}_v - \hat{C}_v)} + \tau[W_c(N_t^0) - W_v(N_t^0)] \times \frac{(\check{C}_v)^2 - [\overline{C}_i(N_t^0)]^2}{2(\check{C}_v - \hat{C}_v)}.$$

Dynamic Big-Box Competition

The sunk costs of entry and incumbents' priority in serving a market make the problem of an entrant using the big-box technology dynamic. To characterize the evolution of big-box competition, consider the dynamic game with only the big-box firms as players and payoffs given by the outcome of the static competition described above. I construct a very simple Markov-perfect equilibrium for this game. It is symmetric in the sense that duopolists' continuation decisions follow the same mixed strategy.

The equilibrium construction begins with the problem of a pessimistic duopolist who believes (irrationally) that the rival firm will *never* exit. Its current profit is $[C_t^0 + M(2)]\pi(2)/2 - \kappa_b$. It will earn this until the next time that C_t^0 changes, at which point the new demand value will be statistically independent of its current value. The conjecture that the rival will never exit allows us to show that the following piecewise-linear function of C_t^0 gives this duopolist's value.

$$v(C_t^0, 2) = \begin{cases} \dfrac{1}{1-\beta(1-\lambda)} \left\{ \dfrac{[C_t^0 + M(2)]\pi(2)}{2} - \kappa_b + \beta\lambda\tilde{v}(2) \right\} & \text{if } C_t^0 > \underline{C}_2 \\ 0 & \text{otherwise.} \end{cases}$$

Here, $\underline{C}_2$ is the largest value of C that sets $v(C,2)$ to zero and

$$\tilde{v}(2) = \int_{\hat{C}}^{\check{C}} \frac{v(C', 2)}{(\check{C} - \hat{C})} dC'.$$

Let $\overline{C}_2$ be the unique value of C which sets $v(C, 2)$ to φ_b. If C_t^0 exceeds this threshold, then creating a duopoly through entry is rational given the pessimistic expectation that the incumbent will never exit.

The next step is to consider the problem of an incumbent monopolist that expects

- the potential entrant will actually enter if and only if $C_t^0 \geq \overline{C}_2$, and
- the potential entrant will never exit following entry.

With these expectations, the value of such a monopolist is also piecewise linear in C.

$$v(C_t^0, 1) = \begin{cases} v(C_t^0, 2) & \text{if } C_t^0 \geq \overline{C}_2 \\ \dfrac{1}{1-\beta(1-\lambda)} [C_t^0 + M(1)\pi(1) - \kappa_b + \beta\lambda\tilde{v}(1)] & \text{if } \underline{C}_1 < C_t^0 < \overline{C}_2 \\ 0 & \text{otherwise.} \end{cases}$$

In parallel with the case of the pessimistic duopolist, $\underline{C}_1$ is the largest value of C that sets $v(C, 1)$ to zero and

$$\tilde{v}(1) = \int_{\hat{C}_v}^{\check{C}_v} \frac{v(C', 1)}{(\check{C}_v - \hat{C}_v)} dC'.$$

Entry places this incumbent into the position of the pessimistic duopolist, so $v(C, 1) = v(C, 2)$ if $C \geq \overline{C}_2$. Otherwise, this incumbent expects to earn the monopoly profit until either C decreases below $\underline{C}_1$ or increases above $\overline{C}_2$.

The players in this game are any initial incumbents and the entire sequence of potential entrants. A Markovian strategy for a player is a pair of functions $A_s(N, C)$ and $A_E(N, C)$ which give probabilities of survival and entry as a function of the number of incumbent firms and the current demand state. A strategy forms a symmetric Markov-perfect equilibrium if any action it prescribes with positive probability yields a weakly higher payoff than any other action given that all other players follow the same strategy.

Consider the following strategy built from the value functions $v(C, 1)$ and $v(C, 2)$.

$$A_E(0, C) = \begin{cases} 1 & \text{if } C > \overline{C}_1 \\ 0 & \text{otherwise,} \end{cases}$$

$$A_E(1, C) = \begin{cases} 1 & \text{if } C > \overline{C}_2 \\ 0 & \text{otherwise,} \end{cases}$$

$$A_S(1, C) = \begin{cases} 1 & \text{if } C > \underline{C}_1 \\ 0 & \text{otherwise,} \end{cases}$$

$$A_S(2, C) = \begin{cases} 1 & \text{if } C > \underline{C}_2 \\ p(C) & \text{if } \underline{C}_1 < C < \underline{C}_2 \\ 0 & \text{otherwise} \end{cases},$$

where

$$p(C) \equiv \frac{v(C, 1)}{v(C, 1) - \{[C + M(2)]\pi(2)/2 - \kappa_b + \beta\lambda\tilde{v}(2)\}}.$$

Verifying that this strategy forms a symmetric Markov-perfect equilibrium begins by showing that $v(C, 1)$ and $v(C, 2)$ give the values of a monopolist and duopolist when all firms follow this strategy. The key to this is to note that the mixed strategy $p(C)$ yields an expected payoff of zero to a firm that chooses not to exit. Such a firm trades off low duopoly profits (partially offset by the probability of a favorable later realization of C) with the possibility of outlasting the rival and becoming a monopolist. With this established, deviations from the given strategy cannot improve either firm's payoff by construction.

Equilibrium Summary

How would data generated by this equilibrium appear to an econometrician? The big-box sector will be either empty, a monopoly, or a duopoly at any given moment. Changes in demand will shift it between those three states. If we think of each village's independent producer as an establishment, then the econometrician observes entry when the village acquires a producer and exit when the village's producer exits. These changes will arise from idiosyncratic village-level demand shocks and in response to changes in the big-box sector. Specifically, an increase in C_t^0 can induce big-box entry, thereby lowering prices and drawing villagers with low transportation costs to the city. This lowers the profitability of operating the independent technology in a village of any given size, so the expansion of the big-box sector comes at the expense of the independent producers. Accordingly, the number of independent producers shrinks. These dynamics mimic the salient facts Jarmin, Klimek, and Miranda document: big-box and independent retailers compete for the same customers, and the entry and exit rates of both types of firms are positive.

What is to be Done?

The present model helps us see Jarmin, Klimek, and Miranda's findings in the context of a single market outcome. While that in itself could be helpful and might inspire the creation of new stylized facts, it is only one small step towards quantifying the welfare and productivity contributions of chain retailers. Although the model has some obvious shortcomings, addressing all of them is not the most obvious high marginal product task at hand. I would like to focus my conclusion on one task that is central: understanding the possibilities for technological change and diffusion in the retail trade sector.

Big-box retailers (and before them chain retailers) have a well-deserved reputation for deploying new technology. The macroeconomic consequences of this are large, as documented by Basu, Fernald, Oulton, and Srinivasan (2003). Nevertheless, there exists no consensus view on the constraints and possibilities for developing retail technology. Are most innovations accidental or the outcome of deliberate research? How do leading-edge technologies diffuse from their origin to the industry as a whole? How important is true innovation relative to imitation of other industries' practices? Without answers to these questions, it will be hard to judge how impeding chain store development changes growth and welfare. I expect answers to come from theory, case studies, and further econometric work on large enterprise data sets.

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