10 Should We All Become Corporate Business Managers? A Different Perspective on Invaders

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Abstract

Based on two articles from popular magazines, the reasons why ecological theories are being applied to modern, knowledge-based businesses are examined. A familiar example of unpredictable invasion success from the computer industry could be a model for explaining some of the limitations on our ability to accurately anticipate only the species which will successfully invade undisturbed habitats.

It is often stimulating to take a look at a familiar topic from a different perspective. Sometimes the most unlikely of sources may set us off on such an exercise. A recent article in the British magazine *New Scientist* was a catalyst for me to reconsider the issue of invasions. This article (Lewin 1997), and one that it cited from the *Harvard Business Review* (Arthur 1996), were ostensibly about economics and modern business practices, but the unexpected connections to ecology and the study of invasions were very interesting.

Before starting, I should emphasize some caveats. Firstly, most of the ideas discussed are taken directly from these two magazine articles. I can only claim originality for trying to link them to our field of interest, invasive plant species. Secondly, I make absolutely no claims to be able to critically assess economic theories. Lastly, this is not intended to change anyone's ecological perspectives, but will, I hope, emphasize how the chaotic complexities of predicting biological outcomes should shape more realistic expectations of modeling plant invasions.

The *New Scientist* article starts by describing three potential invaders. The first was the NeXT computer workstation developed by Apple Computers in the late 1980s.

This easy-to-use and highly capable machine was considered technologically superior to the existing competitors. The second was the Alpha micro-processor chip launched by Digital Equipment Corporation in 1992. At that time, it was more than three times faster than its nearest rival; it was still the fastest chip as of November 1997. The third was an exotic, seed-eating bird superbly adapted to the highland forests of Hawaii into which it had been introduced. (This is now starting to sound more relevant).

The connection between these examples is that all of them failed to invade and dominate the market (or habitat), despite being considered superior to existing competitors. At this point, there may be a temptation to be disappointed, since most readers are likely to be more concerned about successful invaders. This is where a change in perspective can be simulating with regard to invasion theories and thought-provoking in making links to the world of business we may never have considered.

If we ask why each introduction is not always successful, we quickly find ourselves listing factors that are the inverse of those characteristics used as predictors of invasiveness: not adapted to the environment; not prolific enough; not competitive in a robust habitat.

For most invaders, we can quickly determine whether the first two factors are significant and could use them to predict an invasive failure. If a potential invader is suitably adapted and prolific, as the three examples appeared to be, then the question of predicting competitiveness in a robust habitat is crucial. This is where the experiences, and frustrations, of ecology are most pronounced and of greatest relevance to corporate management.

Although a highly important and popular pursuit in ecological research, predicting the outcome of competitive interactions is still a topic fraught with uncertainty and controversy. On the theoretical side are fundamental disagreements over what defines a good competitor. Two well-known perspectives from the competitive world of "theories of plant competition" are those of J.P. Grime and associates, who see competitors as "offensive", pre-emptive exploiters of resources, and D. Tilman and colleagues, who attribute competitive success to "defensive" tolerators which can outlast the competition as resources are over-exploited. Although such theoretical disagreements do not alter the predictive accuracy of competition studies, they are a symptom of the complexity and continuing evolution of this branch of ecology.

While many traditional methods of quantifying competitive interactions, such as additive or substitution experiments, are highly predictive in simple agronomic ecosystems, the competitive balance between two plants may vary depending upon a variety of external conditions. Environmental conditions (nutrient, light and water availability, temperature, pH, salinity, etc.) can modify competitive interactions if they differentially influence growth of the two plants. Different susceptibilities to disturbance, herbivory, or pathogens can also change the direction of a competitive interaction in ways that might not have been predicted under ideal conditions. Thus, even in simplified or highly disturbed ecosystems, accurate predictions of competition under all possible conditions can be elusive. Add the presence of multiple, well-established plant species, as found in most natural ecosystems, and the prediction of which invaders will be competitive becomes much more complicated.

This brings us back to the third factor, mentioned earlier, which may explain why not every introduction is successful: *Invaders may be held out of habitats or markets by existing occupants, even if those occupants would be inferior if directly compared.* This may happen because the existing competitors have established networks and cooperate with each other, which allows them to be more resilient to competition from the invader than they might be in isolated one-on-one competition. Examples of these types of established interactions in plant ecology are not necessarily as well documented or understood as the following, very familiar example from the business world.

The phenomenal success of Microsoft can be attributed to the huge market share obtained by its disc operating system (DOS) for personal computers; this result was not predictable in the early 1980s when the market was opening up. At that time, Microsoft was committed to providing DOS as the operating system for the IBM Personal Computer (IBM PC). The two other competing operating systems were the well-established CP/M and the innovative Apple Macintosh ("Mac"). With its icon-based, user-friendly format, the Mac system rapidly attracted a dedicated clientele and might have been anticipated to be the way of the future. The base of DOS/IBM users was also growing, so software developers tried to write for both standards. The clinching factor was the different strategy of IBM to allow, and Apple Macintosh not to allow, the production of "clones" of their personal computers. This decision, which allowed for the availability of lower-cost IBM-compatible personal computers, rapidly expanded their market share of desktop computers, and along with it, the DOS operating system. Once the DOS/IBM system started to dominate the market, software suppliers were encouraged to write for, and technically support, this system. As users expanded their software capabilities and amount of stored data, it did not pay to switch from DOS/IBM, so these products rapidly "locked-in" the market despite expert opinions that this was not necessarily the best system. Thus, prior to the DOS deal with IBM and the latter's decision to allow personal computer clones, the outcome of the operating system contest would not have been predicted.

In this example, the crucial relationship between the operating system, computer, and software manufacturers. Illustrates how even networks with relatively few components can be complex enough to defy accurate prediction of the outcomes of interactions. It is this concept of networks between distinct business components that has brought the field of ecology to the attention of economists. Viewing the economy as an ecosystem rather than an isolated machine is a perspective that seems to be gathering supporters. This recognition may be rather pleasing to those of us ecologists who have wished for a little more respect from the business community. Before we become too smug, however, we must critically evaluate what experience and help can really be offered in this arena.

How adept are we at predicting invasions or the outcomes of competitive interactions and other important intertrophic impacts, even in relatively simplified ecosystems? The development of tools to predict which species will invade is currently a hot topic and so is likely to continue to improve. As the work of Reichard and Hamilton (1997) on trees introduced to North America showed, it is relatively easy to anticipate which species are likely to invade, i.e., known pest invaders were correctly predicted in 88% of cases and none were incorrectly deemed harmless (the other 12% needed further investigation). It was harder to foresee which species would not become invasive over 60 years: 46% of non-invaders were correctly identified and 18% were falsely assumed to be invasive. This is exactly the reduced predictability of the "failures-to-invade" illustrated earlier in this article.

While we may be capable of conceptualizing some alternative impacts of a species' invasion, we have not necessarily been as successful at clearly defining and executing the relevant studies to predict which outcome would occur. For example, sapodilla (*Manilkara zapota* (L.) P. Royen) is a tree that was introduced to southern Florida for its edible fruit. It is now distributed, and possibly spreading, within some natural habitats such as the Key Largo Hammock State Botanical Site. Its impacts on these natural habitats have not been quantified, but as the home of several endangered subspecies like the Key Largo wood rat, it is important to know whether there are significant impacts (negative or positive) on these communities before a decision is made to expend resources to remove sapodilla or leave it to expand.

Indirect impacts on endangered animals, by way of alterations in native vegetation, could include changes in light, water, and/or nutrient availability under the dense leaf canopy and litter layer produced by sapodilla. More direct impacts on wood rat populations may be their expansion if they are able to successfully utilize the sapodilla fruit as a new resource. Alternatively, the fruit may instead, or also, encourage other animals such as raccoons; these may or may not have a negative impact on the wood rats. With a network of just three components (sapodilla fruit, raccoon, wood rat), the possible consequences of sapodilla's invasion are many and complicated; a large amount of resources would be needed to study a tree and two mammal populations. So ecological systems may be good general models for certain types of economy, but we have not necessarily provided many examples, at least not in the discipline of invasions, of how we can improve our predictions of the impacts of invaders

Ecological theory does provide some historical models that may reassure economists and business managers that the difficulty of predicting ecosystem perturbations is not a problem unique to the marketplace. Looking at theories of biological succession, the Clemensian concept of succession proceeding to a system that is predictable and stable, with self-restoration if disturbed from the equilibrium, has given way to the view that succession is so influenced by the complex internal dynamics of ecosystems that its exact direction cannot be predicted, even if external conditions could be.

Historically, the business world seemed much more stable and predictable than the computer technology examples that have been quoted (Arthur 1996). Following the industrial revolution, economic theories were developed based on "bulk-processing" industries such as production from metal ores, coal, lumber, etc. The economies for these industries are typically based on an assumption of diminishing returns, where products or companies that get ahead in a market finally become limited so that a predictable equilibrium of market share is reached. For example, a coal mine expanding production would eventually be driven to use seams of poorer quality or access and so run into diminishing returns. Production in these industries tends to be repetitive; being competitive means keeping a smooth production flow, reducing costs, and improving quality. Some of the most favorable characteristics for bulk-processing are listed in Table 1.

Table 1. Optimal characteristics of bulk processing and knowledge-based industries.

Characteristic	Bulk processing	Knowledge-based
Changes in production	Repetitive	Dynamic
Long-term competitive goal	Optimize production	Recognize new trends
Management objectives	Cost and quality control	Positioning in markets
Dominant management strategies	Planning	Adaptability
Management structure	Hierarchical (bosses and workers)	Project teams

Knowledge-based industries, such as our examples in computer technology, have a quite different set of characteristics and, hence, management styles. The concept of "increasing returns on investment" was illustrated by Microsoft's "locking-in" of its DOS system to the personal computer market. Once established as a market leader, the development of networks that link various market components, e.g., personal computers, DOS, other software, customers' databases, consolidated that lead and reduced the likelihood of competitors taking away any market share. Instead, the industry starts searching for the next big market. Management is not then production-oriented but is organized around identifying and getting ahead in the next mission. Mission-oriented teams are the favored organization structure rather than hierarchical management, and companies will succeed through adaptability and evolution of ideas rather than through strict production control and optimization.

Again, these descriptions of knowledge-based industries have similarities to ecosystems and evolutionary strategies. This may be familiar territory to biologists, but the implications for Chief Executive Officers (CEOs) of these knowledge-based industries are quite significant. Instead of regarding their industries as smoothly running machines heading towards stable and specified goals, they are having to give up the engineering metaphor for a biological concept of their business as an organism interacting in a complex community. CEOs who have been more used to controlling simple head-to-head business competition may have to adapt to the idea that it may not be possible to predict the next market winner. Ultimately, this will mean accepting that CEOs may have less control over their company's fate than they had assumed, forcing them to view their markets as the unpredictable "jungle out there" (Lewin 1997).

So what are the implications for ecologists and field-based biologists? One important point for those of us working with biological invasions is that we need to remain realistic about our expectations of being able to accurately predict the likelihood and impacts of successful invasions. Identifying organisms that have the potential for invasion based on adaptation to the new environment and fecundity is important and may be fairly accurate for noticeably disturbed habitats. But the likelihood of correctly predicting which species will invade robust habitats is much less. While we may not be worried by the resulting over-cautious opinions that falsely predict dire consequences of certain introductions, we must be prepared to convincingly articulate the reasons for this uncertainty (perhaps using Microsoft's DOS as a familiar example) to those who do not wish to see increased regulations on the importation of non-indigenous species.

On a lighter note, we may find the captains of industry (CEOs, MBAs, etc.) turning up at Exotic Pest Plant Council meetings, trying to get a grasp of how to work in unpredictable ecosystems. On the other hand, who better to take over the management of knowledge-based industries than field biologists who have few illusions about being able to accurately predict, much less fully control, the habitats in which we work. The dress codes may conflict somewhat, but to paraphrase my favorite quote, perhaps we are the most psychologically prepared to deal with unpredictable knowledge-based industries if they are like "field experiments [and] are not for the faint of heart" (Spencer and Whitehand 1993).

Literature Cited

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