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Science, Engineering, and the Discipline of Real Estate

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Abstract

An attempt is made at defining the discipline of real estate by exploring the academic traditions of science and engineering and by developing an activities model of the real estate system. The resulting framework illustrates an applied discipline with four distinct cells of academic endeavor—activities science, allocation science, activities engineering, and allocation engineering. This model of the academic discipline of real estate is both descriptive and prescriptive. It is descriptive in the sense that it efficiently captures the research interests of the real estate academic community. It is prescriptive in the sense that it offers a starting point for the development of a shared definition of what the academic discipline of real estate should be.

Real estate, the academic endeavor, has an identity problem. There have been calls for real estate to define itself, to stake out its territory as a discipline (see for example Rowlands, 1967 cited in Dasso and Woodward, 1980), and many have addressed these calls (Wendt, 1949; Weimer, 1956; Grebler, 1959; Cook, 1974; Graaskamp, 1976). Yet despite these attempts and a renewed interest in defining a real estate discipline (Isakson, 1991; Jaffe, 1992; Seldin, 1991; Grissom, 1992), an identity eludes us. Dasso and Woodward (1980), building on Ratcliff's (1966) characterization of real estate as an "ill defined mutation," express doubt that real estate can ever achieve definition as a distinct field.

Is real estate a discipline? This essay argues that it is—that it is in a class of academic disciplines called applied science and that it has two major research goals and two major foci. The argument is organized into six major sections plus a conclusion. The nature of academic disciplines is introduced in the section entitled Science versus Engineering followed by a treatment of applied science entitled Science and Engineering. The territory of the real estate discipline is developed in An Activities Model of Real Estate, and the fourth section presents A Framework for the Academic Discipline of Real Estate. Finally, Real Estate as Science and Real Estate as Engineering are explored.

1. Science versus engineering

Human beings have always hungered for truth. From the ancient Greeks we have inherited the notion that a discipline must focus on some aspect of nature and must seek to reveal the truth within that focus. Once the purview of philosophy, the responsibility of describing the world has been passed on to science. Popper

(1965) has claimed this purpose for science, and Kuhn (1970) has argued that without a commitment to scrutinize and reveal some aspect of nature, no one is a scientist. To be a scientist means, then, to reveal nature, to advance the body of knowledge within the delineated territory. The scientist seeks to discover what is not known, to describe and generalize these discoveries and light the way for other seekers of knowledge. We may argue about method. We may even argue whether truth is manifest. But there can be no argument about the aim of science. To describe nature is the scientific imperative.

While humanity has sought to reveal its world, it also has struggled to better that world. These efforts apply the fruits of scientific endeavor—knowledge about the natural world—to create a technology to improve human existence. This technology takes many forms, including hardware, computer programs, solution processes, heuristics, policies and procedures, algorithms, and models. The disciplines charged with developing technology are disciplines of engineering, and although often confused with science, they have a very different aim. The engineering imperative is not to create knowledge but rather to use knowledge to create improvement.

A special case of scientific endeavor occurs when human activities become the focus of study, the delineated territory. Simon (1981) classifies such scientific interest as sciences of the artificial as opposed to natural sciences. The world of humanity—its objects and phenomena—is thereby distinguished from the world of natural objects and phenomena. This division of science into natural and artificial worlds is itself somewhat artificial since men and women and their outputs are no less a part of nature than ants and their colonies or pulsars and their waves. Yet the distinction is useful because when humanity becomes the object of study, the scientific imperative to create knowledge and the engineering imperative to create improvement often merge and even become blurred. The disciplines that form at the cusp of science and engineering are called applied disciplines, and they are explored in the next section of this essay. Figure 1, suggested by an

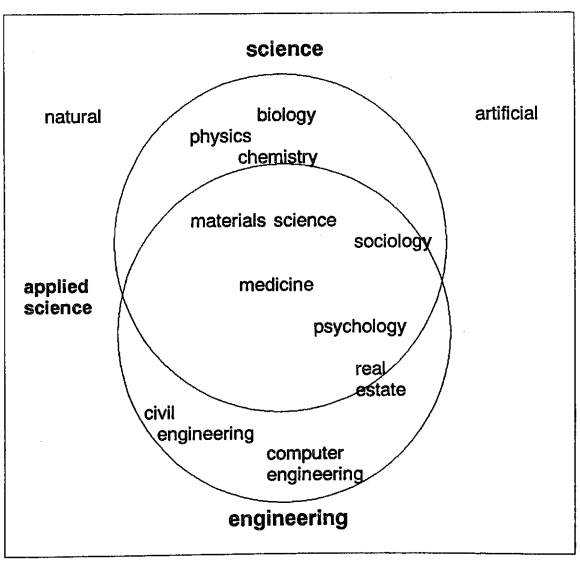

Figure 1. Academic disciplines. (Suggested by an anonymous reviewer.)

anonymous reviewer, depicts the applied sciences as found in the intersection of science and engineering and places several specific disciplines in the formed space. The placements are subjective and are intended to be suggestive rather than precisely definitional.

2. Science and engineering

John Neville Keynes (1955), the father of the more famous Keynes, recognized in 1890 both the scientific imperative and the engineering imperative within economics (political economy). He employed the term *positive* to represent inquiry aimed at what actually is, at discovery, description, and prediction, and the term *normative* to represent inquiry aimed at the ideal, at what ought to be, at prescription for improvement. The duality of imperative is not unique to economics but is a characteristic of psychology, sociology, and most if not all of the sciences of the artificial including the allied business disciplines. But this duality does not occur often if at all in the natural sciences. The reason has to do with the nature of the constituencies served by natural versus artificial disciplines.

A scientist of the natural world serves only the human need to know—that is, his own curiosity, the curiosity of the scientific community, and that of humanity. Observers of the artificial world, the world of phenomena created by human beings, serve natural curiosity, and because they study issues directly relating to men and women, they also serve a constituent body of potential users of whatever knowledge is discovered. The relative eagerness of the constituency to use the fruits of artificial scientific endeavor determines the strength of the engineering imperative within a given artificial discipline. The business disciplines, for example, have very eager constituencies that sometimes even show disdain for any knowledge not obviously and immediately of "practical" use branding it "theoretical"—meaning, of course, of little real value. With such demanding constituencies, the engineering imperative becomes very strong, and most business disciplines become largely disciplines of engineering.

What keeps applied disciplines, including business ones, from imploding entirely into engineering is the need for knowledge, the need for science. Friedman (1953), Brightman (1978), and doubtlessly others have pointed out that normative inquiry is built on positive inquiry. Engineering requires knowledge. Without a science feeding it knowledge, an engineering discipline has no alternative but to develop its own knowledge generation, its own science. At the very least a normative discipline will harvest the knowledge generated from other disciplines and harness it to its own engineering purposes.

These, then, are the applied sciences, disciplines that generate and borrow knowledge to be immediately engineered into ways and means that can lead to the improvement of the constituent's world. Real estate is one of these disciplines, and to better understand it, we must delimit its territory.

3. An activities model of real estate

Efforts to delimit and define the territory of real estate are confronted by a confusing thicket of diverse activity—lending, investing, governing, developing, con-

suming, marketing, appraising, and more. Perhaps nothing accounts so much for the lack of consensus among real estate academics as does this challenging richness. Yet there is form to this tangle, and a key to revealing this form is the concept of economic activity. Economic activity may be viewed as the process of generating the supply of or the demand for some economic good. Thus the world of real estate becomes less a collection of lenders, investors, and governments than a system of lending, investing, and governing, less a mosaic of individuals than an organism of interrelated activity.

What excites this organism of real estate into life is the entrepreneurial activity—the activity of creating, managing, and trading space over time. The equity entrepreneur responds to some market stimulus, perhaps the demand for space or the supply of capital, by demanding the goods and services generated by other activities, combining these goods and services with its own skills, and creating space to meet human needs. This space is managed or is traded to space users or to other equity entrepreneurs who have utility for the income generated from users of space. The entrepreneurial process may or may not involve construction, for all users of real property require entrepreneurship at some level. Parks, farms, and wildlife sanctuaries are examples of land uses requiring entrepreneurial activity but little or no construction, and land speculation, subdivision development, and assemblage are real estate entrepreneurial activities not typically requiring the building of structures.

Popular usage has engendered a traditional and even stereotypical connotation to the term *entrepreneur,* but private individuals, a group of individuals, a corporation, or even a government entity may engage in entrepreneurial activity. An excellent example is the effort, documented in Frieden and Sagalyn (1990), of local governments to revitalize retailing in declining downtown areas. Creating, managing, and trading space, the essence of real estate entrepreneurship, require risk taking. With nontraditional entrepreneurs the nature and level of risk assumed may change—for example, there may be political as well as economic risks—but inevitably there will be risks associated with entrepreneurship.

Whether involving traditional or nontraditional parties, the entrepreneurial activity lies at the heart of the real estate system and arouses the other, surrounding centers of economic activity—the lending and investing activities, for example. The links between the activity centers are formed by markets that allocate the goods and services produced within activity centers to other activity centers. These market linkages are the conduits for economic stimulus being pulsed through the system. Markets themselves are activities, but they are quite different from centers of economic activity. Activity centers represent the independent activity of individual entities generating supply or demand, whereas markets represent the interaction of individuals trading for economic goods.

This system of real estate may be pictured as a network as shown in figure 2, where nodes portray activity centers and arrows portray the markets linking them. Given its cardinal importance, the entrepreneurial activity center is depicted as the heart of the scheme and is numbered 1. The entrepreneurial activity must bid for capital, both equity and borrowed, by promising a return and therefore is linked to investor and lender activities (numbered 2 and 3) by the markets for capital. The entrepreneur attracts investment capital by projecting project performance and by offering ownership interests entitling equity investors to share in project benefits either in the form of cash flow from operations, proceeds from

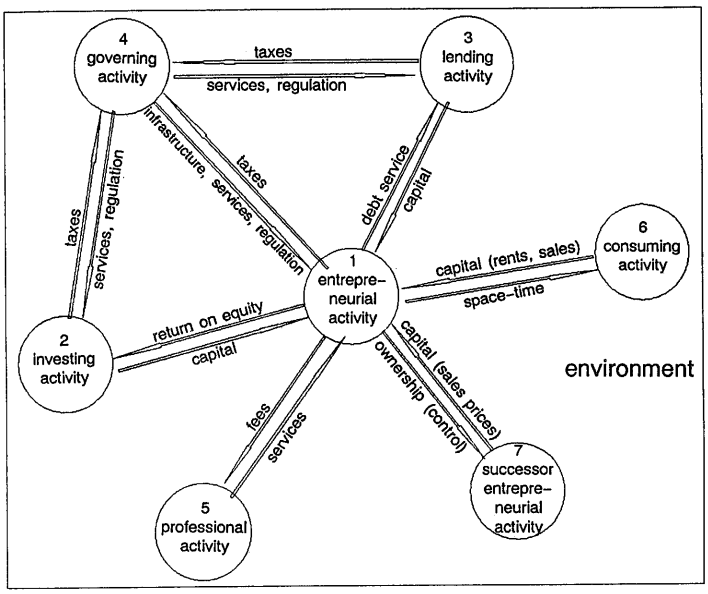

Figure 2. The real estate activities model.

sale, or tax shelter. The investor–entrepreneur connection therefore consists of capital flowing from investors to entrepreneurs and of capital returns flowing from entrepreneurs to investors. The lender–entrepreneur connection is formed by the flow of capital from lender to entrepreneur in exchange for the flow of contractually defined debt service. Both lender and investor capital markets distribute capital and price it at rates reflecting project and ownership risks.

A fourth important center of economic activity is government. The interaction between government activities and entrepreneurial activities offers infrastructure, services, and regulation from governments in exchange for taxes from entrepreneurs. There are similar interactions between government activities and investor activities as well as between government activities and lender activities. These links between government and other centers of economic activity are not strictly markets but nonetheless accomplish the market function of resource allocation. Nonmarket resource allocation mechanisms include budgeting, negotiating, balloting, lobbying, and assignment. A fifth center, that of professional activity, enjoys a traditional market link to the center of entrepreneurial activity. Here labor—in the form of services such as legal, accounting, appraisal, construction, and marketing—is exchanged for fees.

Investors, lenders, governments, and professionals form supply centers for the real estate entrepreneur, while the final two activities depicted in figure 2 are centers for demand. Real estate consumers, activity center 6, have utility for the physical characteristics of real property and are linked to the entrepreneurial activity by the market for space over time. Real estate entrepreneurs provide this space to real estate consumers in exchange for capital in the form of rents and purchase money. The final activity center is populated by those having utility less for the physical characteristics of real property than for the income it generates over time. The successor entrepreneurs of activity center 7 rise up to take the

place of previous ones, trading capital for ownership and control in order to provide and manage space. This new center of entrepreneurial activity is itself linked to lending, investing, governing, professional, consuming, and successor activities that are not shown in figure 2 in order to preserve simplicity.

Simplicity is likewise preserved by eliminating from figure 2 some activity centers, such as secondary mortgage market agents, and by not picturing all activity center linkages. The government–professional and government–consumer connections are not shown, nor are other important linkages that exist between the centers of real estate economic activity and other centers of economic activity that lie outside the realm of real estate. The relationship of real estate to this "outside" world of activity can be modeled by encasing the real estate network within an enclosed environment. The nature of the relationship between real estate and environment is dynamic and mutually causal. While the real estate process is shaped by the political, social, economic, and physical environment, the real estate process also contributes in significant ways to the form of those environments.

A few final comments on the robustness and flexibility of this concept of real estate are appropriate. The activity centers depicted need not be conceptualized as separate entities. A single entity may engage simultaneously in several activities. An entrepreneur may be the sole equity investor and also may provide nonentrepreneurial professional services. A local government may form a coalition with a private developer in an entrepreneurial effort to revitalize its downtown. A lender may equitize some of its interests, becoming an equity investor while maintaining traditional security positions. In each case a single entity has engaged in distinctly different economic activity. Employing the real estate activities model of figure 2, each activity would be modeled as a distinct center with resource allocation interaction linking them. Resource allocation mechanisms connecting distinct economic activities within single entities would not likely be traditional markets but could be budgeting, negotiating, or balloting. Such nonmarket allocation mechanisms are characteristics of links between government and other activity centers as well as links between activity centers when a single entity engages in multiple activities. The accelerated interest of corporations in real estate entrepreneurial activity should increase the amount of nonmarket links between activity centers.

While the activities model brings form to the challenging diversity of real estate, it nonetheless portrays a complex organism of vital economic activity connected through a rich interlacing of resource allocation channels. The complexity of the organism is passed on to the discipline devoted to studying it. But the activities model can be used to reduce the complexity and to bring structure to the academic discipline of real estate. This attempt at explication through reduction is offered in the next three sections.

4. A framework for the academic disciplines of real estate

A researcher may have either prescriptive or descriptive interests, and further, any aspect of the complex realm of real estate may serve as a focus for study. The number of real estate academic perspectives therefore seems countless, but they can be collapsed into a manageable number of groups by using the activities model. This reduction is demonstrated in figure 3 which defines the real estate

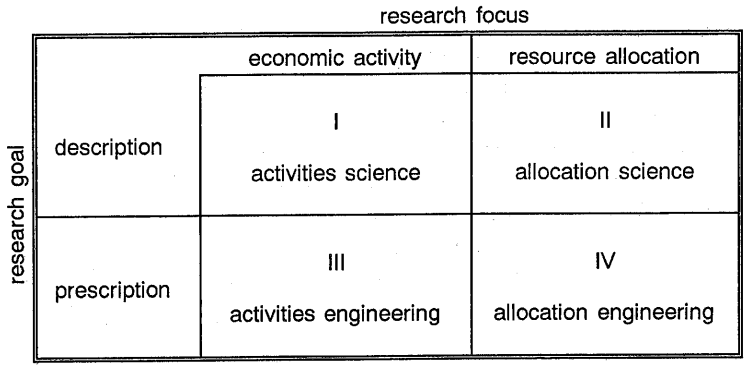

Figure 3. A framework for the real estate discipline.

discipline in two dimensions, research focus and research goal. Real estate research can focus on one of the two components of the activities model, on either economic activity centers or on resource allocation activity. Research goals may be descriptive (that is, scientific) to generate knowledge or may be prescriptive, to engineer improvement. Four distinctive cells of real estate academic endeavor result—two devoted to the scientific imperative and two devoted to engineering.

Any framework that attempts to define a discipline should be evaluated by several criteria. A framework should be complete yet concise. When a framework captures the full richness of its subject, it exhibits completeness. Conversely a concise framework should have as few categories or cells as possible. By employing the two major dimensions of the activities model and the two general interests of academia (knowledge and improvement), figure 3 presents a concise yet complete framework for the definition of the real estate discipline.

A framework claiming to define a discipline should also be consistent and mutually exclusive. If dimensions and dimension values are defined clearly and can be used logically to categorize research issues within the discipline, the framework is consistent. If each category or cell represents a unique set of issues, the framework is mutually exclusive. Mutual exclusivity does not mean that research cannot span more than one cell, for any research project may have multiple elements and may embrace more than one set of research issues. An individual paper that addresses more than one research issue may belong to more than one cell. This is not a failing of the mutual exclusivity of the framework but instead is an expected consequence of multifaceted research. The faithful application of the logic of the framework results in consistent and mutually exclusive categories of research issues even when individual projects fall across cells.

Finally, a framework must be fruitful. It must provide orientation and perspective, a heightened awareness of the subtle interrelationships that bind together the diversity of the field. By doing this, a framework becomes an agenda for the discipline, organizing what has been done and pointing out promising areas of neglect.

5. Real estate as science

To science falls the charge of fostering our understanding of the world. The work of science is the generation of knowledge. The real estate positivist therefore

seeks to reveal actual human behavior within real estate. This work can be theoretical—it can develop or extend theories that predict and explain human behavior—or the work can be empirical. A real estate empiricist studies behavior by observing it in the laboratory or in the field or more commonly by interpreting and modeling the artifacts of behavior, such as sales prices.

While the real estate positivist may engage in empirical work, not all empirical work is positive. Some empirical effort seeks to explicate not human behavior but rather the performance of a decision aid, tool, or policy. Such studies are engineering in nature, for they do not aim to describe human behavior but rather to improve the result of human behavior by discovering and prescribing the most appropriate—the optimizing—behavior. Research that focuses on human behavior as a dependent variable is descriptive, whereas research with human behavior as an independent variable may not be. For example, an investigator interested in the usefulness of a new sales adjustment technique may decide to examine the precision of the tool by observing appraisers of varying levels of experience using it. Such a focus is prescriptive since the research aims at determining properties of the tool and not at revealing behaviors of the appraisers.

The focus of descriptive real estate research may be on activity centers—that is, on the behavior of individual entities, whether these entities are individual persons, groups of persons, organizations, or coalitions. This research focus is represented by cell I of figure 3. Examples of positive inquiry captured within this cell are the identification of variables associated with residential real estate sales staff performance (Abelson, Kacmar, and Jackofsky, 1990), the comparison of actual appraisal behavior with the prescribed appraisal process (Diaz, 1990), and the examination of factors that encourage the use of debt by REITs (Maris and Elayan, 1990). Alternatively, descriptive research in real estate may focus on resource allocation—on the interaction between individuals vying for limited resources. Placed in cell II of figure 3, some examples of this category of research issues include a test of the random walk hypothesis in the GNMA bond market (Ma, 1990), an examination of the relationships between rent changes and vacancy rate changes (Glascock, Jahanian, and Sirmans, 1990), an estimate of the degree to which extensive magnet school use and public school quality are capitalized into local house prices (Walden, 1990), and an exploration of the agency costs experienced by property owners entering into standard property management contracts (Rosenberg and Corgel, 1990). The use of these examples is not intended to imply that the cited research projects can be assigned unambiguously to a single cell but rather that research questions addressed in them can be.

There are many more examples of real estate research answering the call of the scientific imperative, and much of this positive inquiry employs what can be considered sound scientific method, yet according to Kuhn (1970), these qualities do not distinguish science from other modes of knowledge seeking. For Kuhn, the discriminating quality is the existence of a universally accepted core of theory and methodology that accounts for what is known and provides a guide to fruitful research problems and to their solutions. This tight focus imposes on the scientist a small range of problems that must be investigated in great depth and detail, and such concentration by an entire discipline on a small set of theories, methods, and questions drives the significant progress that, according to Kuhn, characterizes a science. Kuhn somewhat vaguely calls this focus the discipline's central paradigm. A more rigorous attempt at describing the engine that drives science is the

research programme of Lakatos (1974). The Lakatosian research programme has two components—a central hard core whose theoretical elements form the foundation of the discipline and are held by its disciples to be unassailable, plus a protective belt of secondary hypotheses and observations that provide direction for inquiry. The hard core supplies the coherence and the protective belt the drive that Lakatos feels are requisites of science.

Both Kuhn with his central paradigm and Lakatos with his research programme emphasize the role of conformity in fueling the progress of science. A notable alternative voice is that of Feyerabend (1978), whose position, styled "against method," is basically that knowledge-seeking ventures such as science should place no restrictions on questions pursued or methods employed. In such a system competing theories should arise and clash and reveal each other's inconsistencies and weaknesses, thereby improving the general state of knowledge.

What Feyerabend's system does not provide is the coordination supplied by an esteemed central core of theory and methodology to which a discipline's adherents are indoctrinated and committed. The sacrifice of a central focus in favor of Feyerabend's creative anarchy may increase the variety and breadth of knowledge but likely at the expense of a depth of knowledge for any given field. Observable progress within a discipline requires consensus from its community of disciples on which questions are important, on when these questions have been answered, on what these answers are, and on what essential new questions spring from these answers. The proliferation of individual, subjective pursuits may stimulate richness and variety but will also erode the unity of the discipline, disperse its achievements and lessen its epistemological impact.

Real estate as science is an example of a knowledge-seeking discipline lacking the focus of community consensus and therefore characterized by a slowly advancing knowledge base. There is great variety but less depth of progress. The discipline of finance as science presents an opposite case. Here a central theory and methodology (efficient market hypothesis and the capital asset pricing model) have been embraced by a community of researchers and knowledge generation has been rapid and deep. Yet knowledge generation has also been narrow and increasingly esoteric so that the results of cutting-edge research in finance are available to an ever-shrinking few.

There is, then, an apparent continuum of knowledge-seeking disciplines marked at one extreme by creative anarchy with its explosive variety and slow growth and marked at the other by central focus with its explosive growth and confining narrowness. The term *science* tends to be applied to those disciplines found in the central focus realm of the continuum. With its broad territory real estate is unlikely to find a single, central focus capable of embracing its wide range of issues and problems. Other disciplines faced with such diversity of territory have adopted multiple foci and have developed into a set of strong subdisciplines. Biology can be decomposed into physiology, embryology, anatomy, genetics, and ecology. Similarly, geology is defined by the subfields of petrology, mineralogy, stratigraphy, paleontology, structural geology, geomorphology, and economic geology. Grissom (1992) introduces some of the paradigms which might serve as nuclei for real estate subdisciplines. Many more are available from other disciplines. Human problem-solving theory holds promise for positive inquiry within activity centers (see Diaz, 1990 for an example of the use of this theory). Organizational theory may provide focus for studying the growing role of the corpora-

tion in real estate. The efficient market hypothesis has been employed in real estate markets research, but it is more applicable to capital markets than to some other resource allocation activities.

The world of real estate certainly is sufficiently vast to support a discipline composed of several subdisciplines, but the public support necessary to spawn and sustain the requisite multiple academic communities is unlikely ever to exist. The discipline of generating real estate knowledge may be suited to a multiple nuclei, subdisciplinary model, but it will never become such a discipline. It may slide toward the central focus end of the continuum by being pulled by a single focus such as the efficient market hypothesis. Such a movement would concentrate what resources the real estate academic community has on a narrow range of issues at the expense of neglecting many more. But a drift toward a single central focus is not likely since the engineering imperative and the need for a variety of knowledge work against it. For it is the engineering imperative that largely drives an applied discipline such as real estate.

6. Real estate as engineering

Real estate as science can be considered a distinct field of academic endeavor today because there is a unique corner of the artificial world called real estate and because there is an academic community striving to generate knowledge about it. The discipline is vast because the corner of the world under study is vast. With weak general support from society, real estate as science will not likely gather the resources, particularly human resources, necessary to add depth to its vastness. And because of a strong yet varied constituency with a great diversity of needs, the field is not likely to concentrate its resources on a tight focus, abandoning the majority of the real estate organism in order to explore in great detail a small subset of issues. For in the long run, the needs of the served constituency shape an applied discipline such as real estate, and no applied discipline can long ignore its constituents and survive. The engineering dimension to the real estate discipline therefore is crucial.

Real estate as engineering is represented in cells III and IV of figure 3. Researchers operating within these cells employ knowledge generated from positive real estate endeavor (cells I and II) or borrowed from other disciplines and forge means of improvement. The normative researcher need not develop new techniques or tools. Prescriptive effort may seek to define the conditions under which a technique should be used, test its assumptions, enhance it, discover new applications for it, or even debunk it. It may focus on algorithms, heuristics, procedures, policies, or models. It may suggest how to gather data, organize data, display, or evaluate data. It may even identify what data should and should not be employed if results are to be optimized. A special class of prescriptive endeavor suggests how descriptive research should be conducted. Such effort typically develops or tests research tools, calibrates instruments, and in general aims to increase the accuracy, standardization, and scope of empirical work in the field.

Within cell III occurs the work of prescribing means of improvement to centers of real estate activity. This is a very energetic and diverse area of academic effort. Recent examples of this work include the development of optimal policies for the disposal of troubled properties (Crockett, 1990), the creation of investment strat-

egies under conditions of inflation (Phyrr, Born, and Webb, 1990), and the illustration of a procedure to include the cost of mortgage commitments in the pricing of mortgage loan rates (Kutner and Seifert, 1990). Cell IV represents normative work in resource allocation, which generally involves optimal methods of accomplishing policy goals. For example, a discussion of some of the market engineering issues surrounding mortgage choice is presented in Follain (1990).

Although an engineering discipline needs no central focus to drive it efficiently, it does require clear goals to direct its efforts. For the two different aspects of normative real estate—activities engineering and allocation engineering—these goals are quite different. Activity centers seek to maximize utility, which may be measured in terms of monetary risk and returns (whether in a portfolio or single asset environment) or in terms of public welfare, contributions to corporate profits, political goodwill, or whatever other measure is relevant to the situation.

The goals of allocation engineering are broader in scope than those of activities engineering and may be in conflict with them. Society has a vested interest in the efficient allocation of resources, and allocation engineers develop means that policy implementors can employ to augment and facilitate resource allocation. Efficient resource allocation may lead to satisfactory suboptimal results within activity centers. Likewise optimization in any one activity center may be at the expense of global allocative efficiency. So while real estate as engineering is united by the engineer's goal of improvement, the specific goal of the allocation engineer, allocative efficiency, may be incongruent with the optimization goals of the activities engineer.

7. Conclusion

What joins the engineers—the goal of improvement—separates them from scientists, who seek to reveal. But what melds the scientist and the engineer into the confederation of an applied discipline is a shared territory complete with a constituency hungry to use the fruits of research. This essay has offered a descriptive model of the world of real estate and has proposed that this picture of real estate as an organism of activities is indeed the territory of an applied academic field. The image that has emerged of a discipline composed of four interlocking cells of endeavor, activities science, allocation science, activities engineering and allocation engineering, is both descriptive and prescriptive. It is descriptive because it can capture in a consistent, mutually exclusive fashion the issues of real estate research. It is prescriptive because today there is no shared sense of a real estate discipline, but there should be. Academic real estate may never become a highly focused discipline for reasons argued earlier, but it needs to become a harmonious one. A general definition of what we are, an understanding of the interlocking relationships of the research we perform, cannot help but heighten the relevance of our work, improve the coordination of our efforts, and advance the dissemination of our results.

We have the mission of applied science—to create or borrow knowledge in order to engineer improvement for an underlying constituency. The work of science may be more glamorous, more rewarding or satisfying, but an applied field that ignores its engineering responsibilities imperils itself. The academic field of real estate cannot neglect the needs of its constituents. We are largely neither scien-

tists nor engineers but rather applied academics who must be prepared to do the work of both science and technology in order to meet our mission. This essay offers no definitive answers but only an invitation for dialogue and debate so that we may come to understand more clearly this mission and so that we may more effectively cooperate to accomplish it.

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