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Behavior of land developers: planning and the economics of information

P V Schaeffer, L D Hopkins
Department of Urban and Regional Planning, University of Illinois at Urbana-Champaign, 1003 West Nevada Street, Urbana, IL 61801, USA
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Abstract. Previous attempts to describe or model planning behavior have failed to focus on a decision variable for the activity of planning itself. Attempts to use economic theory to explain planning by modeling only the phenomena being planned for have not been useful in explaining or understanding planning behavior. The model developed in this paper for land development planning makes explicit the decision to plan at each stage of the development process. It also makes explicit the plan at each stage, in the form of a contingent set of expected decisions. These strict definitions make possible progress in understanding planning behavior.

1 Planning in private land development

Planning plays an important role in land development because planning yields information. Information is valuable because many decisions in land development are very costly to change once they have been acted upon.

Following Friend and Jessop (1969), we use planning in the narrow sense to refer to the activity of producing information to reduce uncertainty with respect to decisions. Planning is treated in this paper only in terms of information produced as an input to making decisions, whether in the public or private sector (Hopkins, 1981). The basic concept of the value of information is taken from decision theory (for example, Auriel and Williams, 1970; Hilton, 1981; Raiffa, 1968). Riker and Ordeshook (1973, page 23) have expressed the search for alternatives in the same form.

This paper focuses on the planning behavior and the role of information in private land development. The public sector also does planning for its own decisions regarding land development. These decisions might include its role as a public-sector developer or its role in establishing regulations for private developers.

In this paper we do not focus on the activities of a particular kind of public planning agency. Public planning agencies carry out several kinds of activities, not just planning in the sense of producing information (Friend and Jessop, 1969). To develop a useful theory of planning behavior we must distinguish among these activities.

In the present formulation we recognize the public sector only in its role in regulation, that is, in the setting of rights. Regulation changes the range of permissible alternatives or the incentives to act in a particular way (for example, Posner, 1974; Riker and Ordeshook, 1973), whereas planning changes the information on which a decision is based. It is true that public agencies plan for this role of setting rights, but that planning activity will be the subject of another paper. We do not model explicitly the regulatory behavior of a public agency, but only the private developer's interaction with an evolving set of rights. The model formulation, by including rights and development actions, is rich enough to allow us eventually to consider the relationships of planning by developers (whether private or public sector) and planning by regulators.

2 Planning and economic theory

Economic theory has been used in two ways to discuss and interpret planning. On the one hand, the market-failure literature on public goods and externalities has been used to argue the need for public-sector intervention. This argument has been extended to planning (for example, Moore, 1978) without taking into account the distinction between planning and collective action. This approach has, therefore, not been sufficient to explain or to help understand observed planning behavior. The fundamental notion of a public good, or a public good externality, is that, *even* with perfect information, individual agents will usually not act to provide the appropriate amount of a good (Baumol and Oates, 1975; Stigler, 1974). If planning produces only information, it cannot cope with public goods. Regulation or collective action is necessary to provide appropriate amounts of collective goods. Planning for regulatory or collective action decisions may be beneficial, but it is regulation or collective action that directly affects the production behavior of collective goods, not planning.

On the other hand, there is the literature on economic planning (for example, Heal, 1973). In this literature the characteristics of optimal plans are addressed, not the activity of planning itself. These models do not include the level of planning activity as a decision variable. The state of information is taken as given. By contrast, a theory of planning behavior must explain how much is expended on planning relative to future decisions and events (Hopkins, 1981). One of the fundamental questions in the organization of planning is the relationship between planners and decisionmakers. The communication between them cannot be analyzed without making the distinction between planning, as the production of information, and the decisionmaking about those activities for which planning is undertaken.

In this paper we draw on the economics-of-information literature (for example, Akerloff, 1970; Hirshleifer, 1971; Marschak, 1974; Popkin, 1981) to develop a model of planning behavior. Development of a formalized theory of planning behavior forces us to clarify our understanding of the relationship between the decision to produce the intermediate good—information—and the decision to produce the final good. Information is an intermediate good because it is used as an input to the decisionmaking process relative to the final good. Planning can, therefore, be analyzed as the production of information as an intermediate good.

Planning in the context of land development is described in section 3. The model is described in section 4. In section 5, given the precise definitions of planning and development activities that the model helps us to make, we address some of the implications and the interpretive potential of the approach. The model as presented here is intended to help us think clearly, not to derive specific analytical results. Empirical investigations and normative interpretations can, however, be developed from this approach. Procedures being developed in empirical work, and examples of normative proposals for the organization of planning activities, are identified in the conclusion.

3 Planning and the land development process

Land development is chosen as an example because of the importance of planning in the land development process (Barrett and Blair, 1982; Henderson, 1980; Ohls and Pines, 1975). Information is valuable because the characteristics of the land development process, and the characteristics of its output—built form—make decisions costly if, in retrospect, they turn out to have been incorrect. These characteristics apply both to private-sector and to public-sector developments. Land development is a time-consuming production process. Production decisions have to be made

long before demand is revealed. Built form is a durable good. Once it is produced, it is very costly to change its attributes. Last, land development projects tie up a substantial portion of the working capital of a decisionmaker (DM). Output decisions based on demand expectations that are not met can seriously endanger the DM's financial liquidity and limit the ability to take corrective actions or to engage in new projects.

The conditions under which planning takes place change during the land development process. It is useful to distinguish three separate phases in order to understand how planning behavior may change as land development proceeds. The three phases are the acquisition, approval, and construction phases.

Land development is conditional on the availability of developable property at specific locations. Property at other locations is usually a good, but not perfect, substitute. Thus land, the major input in the land development process, is of heterogeneous quality. The quality differences include location, zoning, lot size, topography, soil conditions, infrastructure, local tax rates, and neighborhood characteristics. The quality of the input land determines, in broad terms, what kind of land development is feasible. The acquisition of the development rights generally precedes any other major development action. The rights to develop the land can be acquired through outright purchase, but it is also possible to lease the land with the right to develop it or to purchase an option.

At the beginning of the acquisition phase, the DM is often uncertain about the characteristics of the input land. Most of this uncertainty will have disappeared when the acquisition is completed. During the acquisition phase "the developer wishes to keep his project from becoming general public knowledge and this also puts the analyst in a difficult position" (Barrett and Blair, 1982, page 9). If the DM is successful in keeping intentions secret, reactions from competing agents such as developers or citizens' groups opposing the project will be delayed. This does not preclude the possibility that resources will be spent on planning to gain information about community attitudes towards the kind of project that the DM is considering undertaking.

Once the rights to develop the land have been acquired, the DM must obtain approval for the specific project desired. If the project stays within the current constraints set by zoning regulations and building codes, the approval should be obtained easily. The DM may, however, want to apply for a zoning change, for a variation of other existing regulations, or for other changes in the rights and obligations attached to the land, in order to undertake the project. In the process of applying for the necessary changes and permits, the full scope and nature of the project must be revealed. Secrecy about intentions is, therefore, no longer possible, so there is also no longer a reason for conducting planning in secret.

At the beginning of the second phase, the DM is uncertain about the possibility of obtaining the desired approvals. It may be necessary to compromise with the regulatory agencies. In the process of negotiation that may precede approval, the final shape of the project will be determined. At the end of the approval phase, most major production decisions will have been made. The DM will usually be left only with the choice to realize the project or to abort it. Under some possible agreements, even this option may be limited. For example, in a planned unit development the developer sometimes must legally commit itself to carry out certain tasks by posting a bond. When construction begins, the only significant uncertainty remaining in conventional projects will be about the final demand.

4 A three-phase stochastic model of planning behavior in land development

The model described in this section provides precise definitions of the planning activity and its relation to land development. With this model, a DM faces a sequential decision problem under uncertainty. Not all decisions become binding at the same time. The DM has the opportunity to acquire information about the decision environment through planning in each phase, as well as by observing the impact of decisions already implemented. Actions taken by other agents may also be revealed. A problem of this kind is called an adaptive decision problem.

To keep the decision problem more manageable and understandable, two simplifying assumptions are introduced. The simplifying assumptions do not reduce the value of the model for achieving conceptual clarity of the theory. First, it is assumed that only one type of built form can be produced, for example, housing. The DM's only decision with respect to the final output concerns the intensity of the development. An alternative interpretation of this assumption is that the DM has the expertise necessary to produce only one type of built form and that it is not economical to learn how to produce another type. Second, it is assumed that the DM is evaluating only one location at a time.

4.1 *Rights in land*

At the beginning of the acquisition phase, the DM may already hold some rights in the land, for example, an option to purchase the land. The rights in the land in each phase are denoted R_t, $t = 0, 1, 2, 3$, where R_0 is the initial rights held by the DM. It is assumed that R_t can be represented as a number in the closed interval $[0, 1]$. $R_t = 1$ denotes the case in which the rights do not impose a binding constraint on the DM's intended course of action. By contrast, $R_t = 0$ is the case where the DM holds no rights in the land at all. It is clear that this representation of rights is restrictive. A more general approach would treat R_t as a vector of different rights and obligations (see Hopkins and Schaeffer, 1983). However, for the purpose of developing an explanatory model of the role of planning in land development, this generalization would lead to more complexity without yielding significantly different insights.

In describing the DM's decisions, we make an important distinction between development decisions and planning decisions. The development decisions are acquisition or sale of rights in land in phase 1 (which we denote x_1); seeking approval from the government for additional rights or for sale of rights in the land in phase 2 (which we denote x_2); and the intensity of the development or sale of rights in land in phase 3 (which we denote x_3). Thus, x_t, $t = 1, 2, 3$, is the notation used for all development decisions.

The decision x_1 determines the level of rights at the end of phase 1, that is, R_1. The decision x_2 and a random variable ε_2 determine R_2. The transitions of the rights from phase to phase are presented in mathematical form below, together with the constraints imposed on x_t. The constraints are a consequence of the range of values that R_t can assume. For phase 1,

$$R_1 = R_0 + x_1, \qquad -R_0 \leqslant x_1 < 1 , \tag{1}$$

where R is the measure of all the rights in land.

For phase 2,

$$R_2 = R_1 + x_2 + \varepsilon_2 , \qquad -R_1 \leqslant x_2 \leqslant 1 - R_1 , \quad -x_2 < \varepsilon_2 \leqslant 0 \text{ for } x_2 > 0 ,$$
$$\varepsilon_2 = 0 \text{ for } x_2 \leqslant 0 , \tag{2}$$

where ε_2 is a random variable that captures the uncertainty about the success of gaining approval. Let R_2^* denote the level of rights eventually obtained.

The formulation implies that a request for approval of additional development rights ($x_2 > 0$) does in no case yield an outcome where rights after approval are less than before ($R_2^* \geqslant R_1$). Although this assumption may occasionally be violated in reality, it yields an accurate description of the vast majority of cases.

For phase 3,

$$\begin{aligned} R_3 &= R_2 , && \text{for } 0 < x_3 \leqslant R_2 , \\ R_3 &= R_2 + x_3 , && \text{for } -R_2 \leqslant x_3 \leqslant 0 . \end{aligned} \tag{3}$$

The first case ($0 < x_3 \leqslant R_2$) is the production of built form; the second case ($-R_2 \leqslant x_3 \leqslant 0$) is the sale of part or all of the rights in the land. If $x_3 = R_2$, then the DM makes full use of the rights to develop the land. A profit-maximizing developer will not necessarily act in such a fashion, however. The extent to which development inputs will be used depends on the unit price dictated by demand, which may not be as high as would be allowed by the rights available.

4.2 *Information and uncertainty*

In making the decisions x_t, $t = 1, 2, 3$, the DM faces several sources of uncertainty. The uncertainty about the approval process, represented by the random variable ε_2, has already been mentioned. At the beginning of phase 1, the DM is also uncertain about the market value of the initial rights in land, R_0; the cost of increasing or decreasing these rights in phase 1; the cost of x_1; and the market value of R_1. Looking even further ahead, the DM is uncertain about the market value of R_2 in phase 2, and of R_3 in phase 3, and about the demand for built form in phase 3.

It may be possible to reduce these uncertainties through planning. In each phase, different planning strategies are available. These strategies are denoted by h_t, $t = 1, 2, 3$. For example, $h_1 = 1$ might mean conducting a geological survey of the land; $h_1 = 2$ might mean conducting a supply study of comparable lots being offered on the market; $h_1 = 3$ might mean conducting a market study for built form; $h_1 = 4$ might mean a combination of all previous kinds of planning. In each phase a discrete number of planning strategies is available. Let H_t be the set of planning strategies available in each phase. Each planning strategy h_t will result in information. For example, a market study will provide information about the current market price of built form and about current and recent actions of competing DMs. The vector of information obtained through planning is denoted y_{ht}, the information obtained from using planning strategy h_t in phase t. Also, y_{ht} is a realization from the outcome space Y_{ht}.

Let $V(R_t)$ be the value of the rights in land held by the DM at the end of phase t. Let $P_0[V(R_t)]$ be the DM's prior subjective probability distribution function of $V(R_t)$ at the beginning of phase 1. The subjective probability distribution is formed by the DM based on the information available. As planning results in new information, this distribution will be revised. Assume that the revision follows the Bayesian transformation rule:

$$\begin{aligned} P_t[V(R_t)|y_{ht}] &= \frac{P_t[y_{ht}|V(R_t)]\, P_{t-1}[V(R_t)]}{P_t(y_{ht})} && \text{if planning is undertaken } (h_t \neq 0) , \\ P_t[V(R_t)|y_{ht}] &= P_{t-1}[V(R_t)] && \text{if planning is not undertaken } (h_t = 0) . \end{aligned} \tag{4}$$

The second equation implies that information can be obtained only through planning. In the same fashion, the DM will revise at the beginning of phase 1 and of phase 2 the subjective probability distribution of the random variable ε_2, the stochastic

influence on R_2:

$$\begin{aligned} P_t(\varepsilon_2|y_{ht}) &= \frac{P_t(y_{ht}|\varepsilon_2)P_{t-1}(\varepsilon_2)}{P_t(y_{ht})} && \text{if } h_t \neq 0\ , \\ P_t(\varepsilon_2|y_{ht}) &= P_{t-1}(\varepsilon_2) && \text{if } h_t = 0\ . \end{aligned} \tag{5}$$

For $t = 1, 2$, $G(x_t|R_{t-1})$ is the cost of changing the rights from R_{t-1} to R_t by an amount x_t. For $x_t < 0$, $G(x_t|R_{t-1})$ is negative and shows the amount obtained from selling x_t rights in land. For $t = 3$ and $x_3 \geqslant 0$, $G(x_3|R_2)$ is the cost of producing built form at intensity x_3. If $x_3 < 0$, then $G(x_3|R_2)$ represents the amount obtained from the sale of x_3 rights in land. For all t, the cost/revenue function $G(x_t|R_{t-1})$ is conditioned on R_{t-1}. Equations (6) show how the DM revises the subjective probability distribution of $G(x_t|R_{t-1})$:

$$\begin{aligned} P_t[G(x_t|R_{t-1})|y_{ht}] &= \frac{P_t[y_{ht}|G(x_t|R_{t-1})]\ P_{t-1}[G(x_t|R_{t-1})]}{P_t(y_{ht})} && \text{if } h_t \neq 0\ , \\ P_t[G(x_t|R_{t-1})|y_{ht}] &= P_{t-1}[G(x_t|R_{t-1})] && \text{if } h_t = 0\ . \end{aligned} \tag{6}$$

Thus, equations (4)–(6) show how the probability assessments of uncertain events change as new information is obtained.

4.3 *Budget constraints*

The DM is constrained in all decisions by the availability of financial resources. Let K_0 be the financial resources available initially. The resources change from phase to phase as the result of actions taken. Resources that are not used can be invested to yield a rate of return α_t. Let $F_t(h_t)$ be the cost of planning in phase t. Then, the financial resources change according to the following rule:

$$K_t = (1+\alpha_t)[K_{t-1} - G(x_{t-1}|R_{t-2}) - F_{t-1}(h_{t-1})]\ . \tag{7}$$

That is,

$$\begin{pmatrix}\text{financial}\\ \text{resources}\\ \text{in phase } t\end{pmatrix} = \begin{pmatrix}\text{rate}\\ 1+\text{of}\\ \text{return}\end{pmatrix} \begin{pmatrix}\text{financial}\\ \text{resources in}\\ \text{phase } t-1\end{pmatrix} - \begin{pmatrix}\text{cost of}\\ \text{development}\\ \text{in phase } t-1\end{pmatrix} \begin{pmatrix}\text{action} -\\ \text{planning in}\\ \text{phase } t-1\end{pmatrix}\ .$$

The constraint imposed by the availability of resources is straightforward:

$$K_t \geqslant G(x_t|R_{t-1}) + F_t(h_t)\ . \tag{8}$$

That is,

$$\begin{pmatrix}\text{financial}\\ \text{resources}\\ \text{in phase } t\end{pmatrix} \geqslant \begin{pmatrix}\text{cost of}\\ \text{development}\\ \text{in phase } t\end{pmatrix} + \begin{pmatrix}\text{cost of}\\ \text{planning}\\ \text{in phase } t\end{pmatrix}\ .$$

Inequality (8) simply states that the DM cannot spend more than is currently available. This implies that $K_t \geqslant 0$, that is, it is not possible to obtain loans to finance the project. This assumption could be relaxed, and for further theoretical investigation of the land development process it should be relaxed. A DM who acquires a piece of land, for example, will usually be able to obtain a mortgage for a large percentage of its estimated market value. This assumption does not affect the initial insight into the planning process and planning behavior provided by the model. That this consideration could be added as an extension demonstrates the richness and clarity of the process that is provided by the model.

4.4 *Maximizing net benefits of planning and development*

The DM is contemplating undertaking a project because of the benefits that may be derived from it. The total net benefits that can be obtained from the project are the sum of the net benefits obtained in each phase, adjusted by an appropriate discount factor. Assume that the DM will make decisions so that the present value of the expected net benefits is maximized. Let π denote the present value of the net benefits for the whole project and let π_t be the net benefits obtained in phase t, $t = 1, 2, 3$. The subscript 1 in the expectations operator in equation (9) expresses the fact that this is the DM's expectation at the beginning of phase 1. The discount factor is $\beta_t = 1/(1+\alpha_t)$. Then, the objective function is

$$\underset{\{x_t,\ h_t\}}{\text{maximize}}\ \mathrm{E}_1(\pi|y_{h1},\ y_{h2},\ y_{h3},\ R_2) = \sum_{t=1}^{3} \beta_t \mathrm{E}_1(\pi_t|.{}_t) \tag{9}$$

subject to constraints (1)-(8).

To finish the specification of the model, we now define $\mathrm{E}_1(\pi_t|.{}_t)$ for $t = 1, 2, 3$. $\mathrm{E}_1(\pi_t|.{}_t)$ denotes the expected net benefit from actions taken in phase t, conditioned on the information available, as perceived at the beginning of phase 1. For notational convenience, a dot is used to represent all the random variables on which the expectations are conditioned. $\mathrm{E}_1(\pi_t|.{}_t)$ is a function of the decisions x_t and h_t. The expectations at the beginning of phase 1 for each phase are defined in equations (10)-(11).

The DM will make a gain or a loss in the acquisition of rights in land in phase 1. The market value of the rights in the land is a random variable, so the DM will look at the expected net benefits:

$$\mathrm{E}_1(\pi_1|y_{h1}) = \mathrm{E}_1[\mathrm{V}(R_1)|y_{h1}] - \mathrm{E}_1[\mathrm{V}(R_0)|y_{h1}] - \mathrm{E}_1[\mathrm{G}(x_1|R_0)|y_{h1}] - \mathrm{F}_1(h_1)\,. \tag{10}$$

That is,

$$\begin{array}{l}\text{expected net benefit} \\ \text{from acquisition}\end{array} = \begin{array}{l}\text{expected increase} \\ \text{in market value}\end{array} - \begin{array}{l}\text{expected cost} \\ \text{of acquisition}\end{array} - \begin{array}{l}\text{cost of} \\ \text{planning}\end{array}.$$

If the DM decides to sell rights, that is, if $x_1 < 0$, then the difference of the first two terms on the right-hand side will be negative, but so will the expected 'costs of acquisition'. Thus, this formulation is general enough to allow either for sale or for acquisition of rights in land.

The net benefit that will be obtained in the second phase is defined in a similar fashion:

$$\begin{aligned}\mathrm{E}_1(\pi_2|y_{h1},\ y_{h2}) = {} & \mathrm{E}_1[\mathrm{V}(R_2)|y_{h1},\ y_{h2}] - \mathrm{E}_1[\mathrm{V}(R_1)|y_{h1},\ y_{h2}] - \mathrm{E}_1[\mathrm{G}(x_2|R_1)|y_{h1},\ y_{h2}] \\ & - \mathrm{F}_2(h_2)\,. \end{aligned} \tag{11}$$

That is,

$$\begin{array}{l}\text{expected net benefit} \\ \text{from approval}\end{array} = \begin{array}{l}\text{expected increase} \\ \text{in market value}\end{array} - \begin{array}{l}\text{expected cost} \\ \text{of approval}\end{array} - \begin{array}{l}\text{cost of} \\ \text{planning}\end{array}.$$

Once again, if $x_2 < 0$, that is, if rights in land are sold rather than more rights sought, $\mathrm{G}(x_2|R_1) < 0$, hence its expectation will also be negative. Before making the decision x_2, the DM may want to undertake more planning h_2. The knowledge gained thereby is added to the knowledge acquired earlier.

For the third phase.

$$\begin{aligned}\mathrm{E}_1(\pi_3|y_{h1},\ y_{h2},\ y_{h3},\ R_2) = {} & \mathrm{E}_1[\mathrm{V}(x_3)|y_{h1},\ y_{h2},\ y_{h3},\ R_2] - \mathrm{E}_1[\mathrm{V}(R_2)|y_{h1},\ y_{h2},\ y_{h3},\ R_2] \\ & - \mathrm{E}_1[\mathrm{G}(x_3|R_2)|y_{h1},\ y_{h2},\ y_{h3},\ R_2] - \mathrm{F}_3(h_3)\,. \end{aligned} \tag{12}$$

That is,

$$\text{expected net benefit from development} = \text{expected increase in market value} - \text{expected cost of construction} - \text{cost of planning}.$$

This shows the expected net benefits of actions taken in the third phase. It is understood that the DM has the option not to develop the property but to sell the rights in land instead, which would be the result if $x_3 < 0$.

Once phase 1 is concluded, the DM faces a new problem. It is now only a two-phase problem. The DM must decide whether or not to proceed with the project and seek approval for it ($x_2 \geqslant 0$), to reconsider the project, for example, by selling part of the rights to a 'partner' ($-R_1 < x_2 < 0$), or to abandon the project completely and sell all the rights in the land ($x_2 = -R_1$). An additional option is to keep rights in the land without seeking approval for a project in the speculative hope that the value of these rights will be sufficiently higher in phase 3 to earn a profit from selling them then. In similar fashion, once phase 2 is concluded, the DM will usually (but not always) have the option to reconsider the project. In the extreme, the DM may abandon it altogether, that is, set $x_3 = -R_2$. In equation (13), the objective function of the decision problem at the beginning of phase 2 is presented. Here y^*_{h1} denotes the realization of the information obtained through planning activity h_1.

$$\underset{\{x_t,\ h_t\}}{\text{maximize}}\ \mathrm{E}_2(\pi|y^*_{h1},\ y_{h2},\ y_{h3},\ R_2) = \sum_{t=2}^{3} \beta_t \mathrm{E}_2(\pi_t|.{}_t)\,. \tag{13}$$

Constraints analogous to (1)–(8) apply for this decision problem.

4.5 *Calculation of expectations*

The way expectations are calculated still needs to be defined. Recall that $\mathrm{E}_1(.)$ always denotes the expected value *at the beginning of phase* 1, thus $\mathrm{E}_1(\pi_3|.{}_3)$ is the expected value at the beginning of the acquisition phase of net benefits obtained in phase 3. The expected value of the rights obtained in phase 1, given a planning outcome, is the product of the value of rights, the probability (P) of that value conditional on information, and the probability of that information being obtained. The expression is integrated over all possible outcomes.

$$\mathrm{E}_1[\mathrm{V}(R_1)|y_{h1}] = \int_{Y_{h1}} \int_{V_{R1}} \mathrm{V}(R_1)\mathrm{P}[\mathrm{V}(R_1)|y_{h1}]\mathrm{P}(y_{h1})\,. \tag{14}$$

Y_{h1} is the sample space of y_{h1}, and V_{R1} is the sample space of $\mathrm{V}(R_1)$. The expectations of $\mathrm{V}(R_0)$ and $\mathrm{G}(x_1|R_0)$ can be defined equivalently.

Expectations about phase 2 variables are slightly more complex:

$$\mathrm{E}_1[\mathrm{V}(R_2)|y_{h1},\ y_{h2}] = \int_{Y_{h1}} \int_{Y_{h2}} \int_{R_2} \int_{V_{R2}} \mathrm{V}(R_2)\mathrm{P}[\mathrm{V}(R_2)|y_{h1},\ y_{h2},\ R_2]\mathrm{P}(y_{h1},\ y_{h2},\ R_2)\,, \tag{15}$$

$$\mathrm{E}_1[\mathrm{V}(R_1)|y_{h1},\ y_{h2}] = \int_{Y_{h1}} \int_{Y_{h2}} \int_{V_{R1}} \mathrm{V}(R_1)\mathrm{P}[\mathrm{V}(R_1)|y_{h1},\ y_{h2}]\mathrm{P}(y_{h1},\ y_{h2})\,. \tag{16}$$

The new element introduced here is R_2, which, unlike R_1, is a random variable. Equation (15) thus includes expectations for planning in each phase, for the value of rights, and for the rights themselves. The expectation (16) expresses the expected value of selling all rights in phase 2 without making any effort to change them first through the approval process. It does not imply that the DM, in phase 2, looks backward and asks how much the right R_1 could have been sold for in phase 1.

That is irrelevant for the calculation of the net benefits in phase 2 because opportunities present in phase 1 are no longer available. Rather, the rights sold are those available at the end of phase 1, not those available at the end of phase 2. As before, the other expected values for phase 2 can be calculated in a similar way.

Expectations at the beginning of phase 1 for variables realized in phase 3 have the same basic form. Equation (17) represents construction, where $x_3 \geqslant 0$, and equation (18) represents sale, where $x_3 < 0$.

$$\mathrm{E}_1[\mathrm{V}(x_3)|y_{h1}, y_{h2}, y_{h3}, R_2] = \int_{Y_{h1}}\int_{Y_{h2}}\int_{Y_{h3}}\int_{R_2}\int_{V_{x3}} \mathrm{V}(x_3|R_2)\mathrm{P}[\mathrm{V}(x_3|R_2)|y_{h1}, y_{h2}, y_{h3}, R_2]\mathrm{P}(y_{h1}, y_{h2}, y_{h3}, R_2)\,. \tag{17}$$

$$\mathrm{E}_1[\mathrm{V}(R_2)|y_{h1}, y_{h2}, y_{h3}, R_2] = \int_{Y_{h1}}\int_{Y_{h2}}\int_{Y_{h3}}\int_{R_2}\int_{V_{R2}} \mathrm{V}(R_2)\mathrm{P}[\mathrm{V}(R_2)|y_{h1}, y_{h2}, y_{h3}, R_2]\mathrm{P}(y_{h1}, y_{h2}, y_{h3}, R_2)\,. \tag{18}$$

Again, the other expected values for phase 3 can be defined similarly. In this formulation, the integration sign stands for the general summation operation. Thus, the equations hold both for discrete and for continuous probability density functions.

5 Interpretations

This model provides explicit unambiguous characterizations of planning to plan, plans, plan revision, and learning from experience. These characterizations provide a base for interpretations about the organization of planning in the public and private sectors.

5.1 *Planning to plan*

The model presents the DM's problem as it appears *before* any action is taken. The DM is considering a particular parcel in which he or she may or may not hold some rights already, and must decide what the best course of action would be. In making the decision, the DM relies on the accumulated experience from previous projects. Development projects are not homogeneous, however, and market conditions change over time, so the DM will usually engage in some planning before taking any other actions. The value of planning in phase 1 is equal to

$$\mathrm{E}_1(\pi|y_{h1}, y_{h2}, y_{h3}, R_2) - \mathrm{E}_1(\pi|y_{h2}, y_{h3}, R_2)\,, \tag{19}$$

that is,

expected discounted profits if planning is undertaken in phase 1 − expected discounted profits if planning is not undertaken in phase 1 .

It is important to understand that the information obtained in phase 1 will influence not only the DM's acquisition decision, but also decisions to be taken in phases 2 and 3. This includes planning decisions, because the knowledge obtained through planning in phase 1 may influence the value of planning in phases 2 and 3.

When the DM takes planning action h_1, he or she will then observe a particular event $y_{h1}^{\star} \in Y_{h1}$. The DM may conclude that the acquisition of the parcel is justified, or may conclude that still more information is valuable and thus engage in planning again. The DM may, therefore, undertake more than one planning action before setting a value for the decision variable x_1. The model does not account for this behavior explicitly, but conceptually the extension is not difficult. If the DM takes no action (chooses $x_1 = 0$) given the information available, then this behavior can be modeled as a repeat of phase 1.

The only decisions that have to be made in phase 1 that cannot be revised later are the decisions h_1 and x_1. Thus, the DM's problem at the beginning of phase 1 is to make optimal decisions h_1 and x_1. Later decisions (h_2, h_3) and (x_2, x_3) will depend on the realizations of the random variables observed in phase 1. At the beginning of phase 1, therefore, when the DM decides on h_1 first and, after observing the realization of y_{h1}, on x_1 second, the decisions h_2 and x_2 will be expressed only as conditional statements. The decisions h_3 and x_3 are conditioned on the realization of random variables in phase 2 in addition to those observed in phase 1. This implies that the DM in phase 1 undertakes planning, makes a decision x_1, and plans not only for decisions x_2 and x_3, but also for decisions h_2 and h_3. That is, in deciding what planning to do now the DM considers what type of planning activities might be undertaken in the future. For example, the DM might plan in phase 1 to take soil samples in phase 3, rather than in phase 1, or to estimate demand for different types of residential units in phase 2, but for residential use in general in phase 1.

This finding is reasonable if we consider the following. Some information is of more value after the DM knows with certainty what are the rights in land (R_t). Almost all information is more reliable if it is obtained close to the time when the event about which this information is sought is realized. Thus, there is a trade-off between getting information early (it may affect early decisions because they are conditioned on expectations from later decisions) and waiting to be closer to the time when the event is realized.

This discussion makes clear the following distinction between a plan of action and a decision to act. A plan is a conditional decision rule with the possibility of recourse as new information becomes available either through planning or through events unfolding, before action is taken. In contrast, a decision to act has a direct effect on rights or construction. Similarly, a plan to plan is a conditional decision rule about planning that would be done in the future. A decision to plan has a direct effect on information.

5.2 *Plans and plan revisions*

The model makes precise a distinction between planning and a plan. At each stage there is a decision about what type of planning to undertake. The variable h_t represents the planning decision. The information to be obtained through planning is represented by the random variable $y_{ht} \in Y_{ht}$. Based on the state of information at any time, there is a set of contingent decisions over each succeeding stage. For example, at the beginning of phase 2 the DM may decide that, based on the information available at that time, it would be optimal to complete the development, that is, $x_3 > 0$. More precisely, we can write $E_2(x_3|y_{h1}) > 0$. This states that at the beginning of phase 2 the DM expects to produce built form in phase 3. But this expectation, this plan, is contingent only on y_{h1}. If planning h_2 is undertaken in phase 2 and the realization y_{h2} reveals new information, the plan may be changed.

Planning should be undertaken if the expected value of the information produced exceeds the cost of producing it. Equation (19) shows this calculation for our model. This is the simplistic rule for plan revision, but other issues, such as the elapsed time required to conduct planning, must be considered to develop a richer explanation. An appropriate time-lagged extension of the model could be developed to address this issue. Information is valuable if it has the potential to change the decision that would otherwise have been made. A planning activity can be undertaken but may result in information that does not justify a change in decisions at this stage or at any future stage. In this case, planning leaves the plan unchanged. A plan for planning is analogously subject to revision. A community's

plan to revise its plan every five years might be revised if the rate of change in the community altered dramatically.

5.3 *Planning and experience*

Once a plan has been made, the actions to be taken are determined contingent only on the outcomes from previous stages, including outcomes from environmental or contextual variables. Decisions are determined more completely as the process of development progresses, regardless of whether there is any additional planning. This process is merely the unfolding of processes over time, not learning. A developer may learn, however, by observing the outcomes of previous development activities and using these to revise probabilities used in future development activities.

Experience gained in previous decision situations is, of course, an extremely valuable source of information. In general, we should not regard the actions that lead to the experience as being planning, because they involve direct actions on rights in land or construction and they are *not undertaken* for the purpose of gaining information. Trial and error may be an efficient way to gain knowledge in some situations. This will often be the case when the consequences of being wrong are not very costly, the elapsed time until outcomes can be observed is short, and the decision environment is stable. These conditions are not commonly met in land development. For example, a developer seeking permission for two similar projects in two different communities may face very different probabilities of successful completion of the approval process $[P_1(\varepsilon_2|y_{h1})]$. The experience in dealing with one community has little bearing on the possible outcome in the other. The experience in the first community is, therefore, of limited value in setting prior subjective probabilities for the second community.

6 Conclusions

Previous attempts to describe or model planning behavior have failed to focus on a decision variable for the activity of planning itself. Attempts to use economic theory to explain planning by modeling only the phenomena being planned for have not been useful in explaining or understanding planning behavior. The model developed in this paper for land development planning makes explicit the decision to plan at each stage of the development process. It also makes explicit the plan at each stage, in the form of a contingent set of expected decisions. These strict definitions make progress in understanding planning behavior possible.

Planning often takes place in a strategic context, and further specification of a model in game-theoretic terms is needed. Some of the strategic issues, such as secrecy of information and the collective good characteristics of planning actions, have been identified (Hopkins, 1981). Batty (1977) has used a game-theoretic approach to explain a British case, but the information production term is not explicit. A model describing the behavior of an agency responsible for a zoning ordinance would be especially useful in clarifying the distinction between planning and regulation.

Empirical investigation based on the concepts in this model has been initiated (Hopkins and Schaeffer, 1983). Using a structured interview that simulates a recursive dynamic programming model, we have collected data about the development of Snowmass, Colorado, from different decisionmakers and from observers of development actions. Collective behaviors consistent with the ideas of Olson (1965) to produce information through planning have been identified among private and public actors deciding to plan.

In addition to empirical investigation, these ideas can be used conceptually to inform the design of organizational structures for planning. By understanding

planning as a production activity analogous to the way we understand land development, we can plan for planning as well as plan for land development.

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