The Bertaud Model:
A two-way mirror on the evolution of information technology's impact on planning for low-income housing

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Abstract

Planners dealing with physical design and financing issues of low income settlement projects have been using the Bertaud model since the early 70's. The World Bank and other major development agencies sponsored this model. In this article I take advantage of this case of long life and wide spread use of a computer model to analyze the interdependencies between the model, its domain and its technological expression. I use the Bertaud model history as a metaphor for a two-way mirror: on one side, I review the shifts of low-income housing policies in the past 20 years to analyze the way they affected the model and its use and how, in turn, the model helped in shaping new policy; on the other side, I review the evolution of the information technology (IT) to analyze how it affected the conceptualization and the use of the model, and which new processes and policies were enabled by the emergence of new IT, through new versions of the model. Finally, I suggest new directions for future versions of the Bertaud model, in terms of use and technological expression, based on this analysis and on the experience accumulated through developing a simple prototype.

Keywords: Bertaud model, Computer based models, Low-income housing.

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Introduction.

Twenty five years ago, computer models made their entrance in policy making for urban planning with the sound of a trumpet, and left the scene shortly afterwards, with the chords of a requiem. This has been the commonly accepted wisdom in planning for many years. But in fact, what changed is the kind of models that were developed and applied, and the role they now play. Today, computer models are more and more indispensable for urban planners and urban policy makers; but their presence is in the background. There are no trumpets, fewer dramatic claims. The Bertaud model is one example of this new style.

The contrast between today and twenty five years ago is sharp. In the late 60's, the discussion of urban computer models was at the center of urban policy debates. A first sign of the emerging enthusiasm was the publication by the American Institute of Planners, in 1965, of a special issue of its journal dedicated to computer modeling. The issue featured, among others, articles by Lowry and Schlager on the design model and mathematical programming methods for policy analysis [Lowr 65] [Schl 65]. Lowry had himself just published "A Model of Metropolis" [Lowr 64]. But the most controversial piece - some say the most influential - was Forrester's "Urban Dynamics" [Forr 69].

Jay Forrester, professor of system dynamics at MIT, applied his methodology to the analysis of the problems of the city, viewed as a social system. The Urban Dynamics model was used to simulate the consequences of traditional urban programs covering jobs, training, financial aid, and low-cost housing. He had no doubts on the absolute need of a computer model for this analysis: Greenberger gives us a thorough account of how *"Forrester considers social systems too complex for the unaided human mind. He attributes 'counter-intuitive behavior' to these systems, behavior that the models of system dynamics can help one to understand* [1] [Gree 76]." Among the conclusions of his Urban Dynamics model, Forrester faulted city fathers for building low-cost housing when they should have been tearing it down [Forr 69]. This was seen as a recommendation of the policy of slum demolition, and soon critics of such policy produced counter-models to contest Forrester's Urban Dynamics [Kada 72] [Ride 73][2]. Schroeder cites policy measures adopted by Lowell, Massachusetts, as evidence of the influence of the urban

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[1] In this article, I will use the convention of *italic* font for brief citations or direct speech quotes from interviews, and idented paragraphs for larger citations.

[2] Rider didn't get the increase in upward mobility, availability of jobs and influx of labor population that Forrester had obtained in his simulations under the slum-demolition policy. Forrester contested that the simulations show a net flow of underemployed into the city under the demolition program; that the reduction in number of underemployed is due to the underemployed moving into the labor category, not out of the city. But also Pack, Babcock, and others contested Forrester results. Greenberger, Crenson and Crissey describe at length this debate [Gree 76].

dynamics model: these include a "tax title program" that *"places extra pressure on the owners of older, low quality property to either upgrade or demolish their structures* [Schr 72]." But despite HUD funding for the urban dynamics study in 1972, those who reviewed the attempts to apply the model to municipalities found that "*most of these attempts did not get outside the classroom* [Gree 76]." Therefore, notwithstanding the heated debates around Forrester's model, the rise and fall of the slum-demolition policy followed a dynamic of its own. Outsiders to this debate, like William Mangin in 1967, were busy exposing the myths and stereotypes of squatter settlements. In 1972, John Turner and Robert Fichter published "Freedom to Build", shaking the urban planner community views on slums [Turn 72]. In the end, it was the work of people outside the modeling debate that had a lasting influence on shifting housing policy.

All things together, the excitement around the "star" computer models in urban planning faded away[1], and by 1973 the curtain was about to be drawn. Reacting, among other things, to the apparent evolution of the computer technology -- bigger and bigger systems, more and more centralized information processes --, Illich and Schumacher wrote influential books defending the advantages of intermediate technologies and low-scale production and organization systems [Schu 73]; in harmony with this trend, large-scale and whole-encompassing computer models came under fire. The final note was played by Douglas Lee's "Requiem for Large-Scale Models" [Lee 73]. As Arbeit points out, "*relatively few articles concerning computing or information systems technology appeared in the mainstream planning literature...for more than a decade after Lee's critical piece* [Arbe 92]." In fact, the echoes of the chords from this requiem are still with us.

But since then conditions have changed. Information technology developments took the direction of mini and micro systems, favoring decentralized access, instead of the feared domination of the mega dimension; and a new type of model came to existence, with less or no fanfare at all, many of them emerging not from academia but from professionals in the field. The focus shifted from models primarily intended to shape policy to models acting as on-site planning aids; from forecasting to analysis of trade-offs (or, according to Greenberger's classification, "conditional forecasting" instead of "unconditional forecasting"). These new generation models are typically not quoted in major policy papers (institutional or academic), but may in fact be (at least some of them) at the core of the analysis done by policy makers. Among them, the Bertaud model, widely known and used but never really published in an academic forum, is perhaps the best example of this new trend.

[1] In the meanwhile, Forrester had moved to a wider arena: from the city level to the world level. His "World Dynamics" was published in 1971 [Forr 71], when the spotlights were focused on the use of world models by the Club of Rome.

The Bertaud model deals with physical design and project financing questions for low income settlement projects. It relates parameters such as land, infrastructure and housing costs, densities and plot sizes, to the required monthly loan payments through several mathematical equations. Alain Bertaud, now with the World Bank, developed the first version in the 70's; since then, it has been used and promoted by major actors in low-income housing projects, institutional (World Bank, National Housing Agencies), and private (PADCO, IDB), in at least 25 countries. In my research, I identified 74 planners that have worked - and some continue to work - with the Bertaud model; undoubtedly, the real number of users is much larger.

Given that the model is still in use after 20 years, this is a remarkable case of long life and wide spread use of a computer model in planning. During a long life, interesting events accumulate; this is no exception. In this case, the Bertaud model's long time-line is intertwined with the parallel evolution of its domain (housing) and of its expression/delivery (information technology). This presents us with a unique opportunity. What can we learn from its history? In the last 20 years, low-income housing policies shifted considerably: from slum bulldozing to slum upgrading, from subsidized housing to sites-and-services with self help, from state-as-provider to state-as-enabler. How did these policy shifts affect the model and its use? And what role - if any - did the model have in the shaping of new policy? During the same time, desktop computers substituted for pocket electronic calculators, which in turn had substituted for slide-rules; general-purpose software substituted for machine-dependent programs. How did this affect the conceptualization and the use of the model? What new processes and policies were enabled by the emergence of new information technology, through new versions of the model? The long and intense life of the Bertaud model provides us with a two-way mirror on the history of the information technology's impact in low-income housing.

During this research, I traced the history of the model and its use, through primary interviews[1] and documentation, such as field reports and analytical papers; collected available implementations of different versions of the model, and experimented with them, for further analysis; identified which changes in the model and its use along version updates are due to feedback from field experience, to the evolution of scientific reasoning, or to the evolution of information technology; identified which changes to the planning process can be attributed to the use of new versions; and, finally, programmed a prototype / demonstration of a possible path of future evolution for the model.

[1] Principal interviewees: Alain C. Bertaud, Senior Urban Planner at the Urban Development Division of the World Bank; Evan R. Rotner, Senior Economist at the Infrastructure Division, Asia Technical Department of the World Bank; Robert D. Daughters, Principal Sectoral Specialist, Urban Development, at the Inter-American Development Bank; Gerald Erbach, Senior Urban Planner at PADCO; Carlos Linares, Associate / Latin America at the Center for International Development and Environment, World Resources Institute.

The first section of this article deals with the model itself, the context in the period of its birth, and intended use. The second section goes into more detail about the impact of the model in planning processes and policies. Finally, a third section examines the impact of IT in the model in terms of use and technological expression, and explores new directions for the future of the Bertaud model, based on this analysis and on the experience accumulated developing a simple prototype.

Among the many limitations of this work, the one that matters the most is the weak base on which to extract solid conclusions on the current impact of computer models in urban planning, based solely on one case - the Bertaud model. Nevertheless, I believe that by improving our understanding of the interdependencies between the model, its domain and its technological expression, we accumulate crucial knowledge for a better generation of planning support systems - and towards a better way of using them. Such is the rationale for the research presented in this article.

O meu povo que trabalha Na auto-construção Porque é qu'essa canalha Não nos dá habitação	Oh my people that work In self-help housing Why those bastards Don't give us habitation
Fazemos casa e palácios Arranha-céus p'rá burguesia E vivemos em barracas Aonde está a democracia?	We build home and palaces Skyscrapers for the bourgeoisie And we live in shacks Where is the democracy?
Agora todos dizem A palavra democrata Eles vivem em bons prédios E nós em bairros de lata	Now everyone says The word democracy They live in good buildings And we live in slums

António Machado
slum-dweller, Lisboa,1975

<u>Section 1: The Context</u>

Slums and Self-help in Lisboa, 1975; Motivation and opportunity - the birth process of a model; The model; Uses and users of the model.

Slums and Self-help in Lisboa, 1975.

One year after the Portuguese revolution, people from the 18 major slums of Lisboa were well organized, had acquired unprecedented political leverage, and their dreams of decent housing seemed about to become true. Then they stumbled on two unexpected obstacles: a new government policy favoring self-help housing, and state staff - good-willed, but upholding traditional regulations and technical approaches.

Some people argue now that the combination of these two factors did what the mighty dictatorship had not been able to: divide, demoralize and demobilize the slum dwellers, the only real driving force behind the housing effort. After all, they say, although many things improved in the low-income housing scene in Lisboa, there still are 18 major slums. But then, in 1975, neither the slum dwellers, nor most planners and technicians of the governmental program SAAL - Serviço de Apoio Ambulatório Local [Port 87], had demobilization in mind.

On the contrary. While some poor families saw the new self-help policy as an opportunity to legalize what they were already doing, and a step towards securing land tenure, many more saw it as a new government trick, through which the state was trying to retreat from full funding of the housing programs. The government was accused of trying to drive the poor to invest the little energy they had left in building their own houses, instead of providing work in paid jobs. There was an acute sense that the right of the poor to fully subsidized housing was an integral part of the democratic revolution.

Planners frequently expressed their frustration, when facing defiant and distrustful slum activists, by wishing they had a better and simpler way to explain the logic of their plans and policies. From their point of view, it was a matter of fact, of technical knowledge, of numbers - things like the limited capacity of state subsidies and the trade-offs between more subsidies or more beneficiaries.

Activists from the "Comissões de Moradores dos Bairros de Lata" (slum dwellers committees) also had an uphill battle in their hands when they tried to argue in favor of their proposals, which the technical staff dismissed routinely -- engineers, for instance, vetoed the sites and favored instead relocation on technical grounds, such as lack of conditions for services, or non-economical site dimensions. Concerned that important values, such as the preservation of community ties, were at risk because of rigid and outdated regulations, the activists always welcomed any technical help they could get to prove the feasibility of their choices. "We won't get nowhere until we throw numbers back at them." "We must learn to beat them in their own game." Anger was also a motivation.

Two years later, the SAAL program was extinct. Some radical groups called the end of self-help housing "a revolutionary victory," but no one smiled at the results. It is difficult to say whether it would have made a real difference, but one thing is certain: the "market" for a tool like the Bertaud model was ready, in Lisboa, in 1975.

Motivation and opportunity: the birth process of a model.

And where was the Bertaud model? In 1975, it was not yet available, but not because of lack of theory. "*I had the equations ready by 1970*", says Alain Bertaud. "*At that time I was using a slide-rule, [and] it was completely impractical. Without something that links all these calculations you can not handle more than 15/50 parameters; if you are doing it by hand you find a different result each time. Let's say, the formula was a mathematical curiosity, but had no practical application, up to the moment of the electronic programmable calculators*". [Bert 92a]

Besides Bertaud, other people were at work on the same concepts. This is one more indication that the model came in response to a real need.

In 1975, Carlos Linares, a former MIT SPURS fellow, was in S. Salvador at the Fundacion por Vivienda Minima doing research, among other things, to come up with a mechanism that would evaluate the efficiency of design of housing projects. "*We knew that we could reduce costs by reducing subdivision standards, and construction materials and systems, but we did not know at that point that a computer model could help us in accelerating the process of looking at alternatives* [Lina 92]." They were able to produce a series of guidelines to improve and rationalize land uses and to look at how land use affected costs, but they were not successful at establishing a formal, model-like relationship. *"Simply because we did not have a tool -- now I realize it, then I didn't realize it; then we thought that there were too many variables, too many unknowns, too many things that affected cost... But I still kept the idea that there ought to be a way of relating the infrastructure development costs and how they affect affordability for low income families and determine housing price and so on, there had to be a link with subdivision standards, with construction costs* [Lina 92]. "

Let us take due note that the model had to wait for programmable pocket calculators. It seems that in 1970 what was missing was new information technology. But then what about mainframe computers, which were already available? Well, among other things, they were not portable; you could hardly access them while working on site. Before analyzing this issue at greater length, it is useful to look further into the context of the model's birth.

In 1975 the Bertauds (Alain and his wife Marie-Agnes[1]) were also in S.Salvador, as PADCO consultants working on a different project (World Bank supported) -- Linares met them and became aware of their work on the model. It is directly based on the experience accumulated from the project in El Salvador, a previous project in Haiti and a consequent one in Thailand, that the first "formal" version of the Bertaud model was born in 1977. Three institutions, at least, were therefore involved in this process: PADCO, the Thai National Housing Authority, and the WB (through CITRUD).

PADCO, "*an international collaborative formed to provide governments and private clients in Africa, Asia, Latin America, and the near East with research, planning and management services for urban and rural development*" (as stated in PADCO newsletters), is a private organization with headquarters in an unpretentious, small building in Washington, DC. With a few permanent staff and a long list of ad-hoc consultants, PADCO is a major actor at the international level, and a frequent World Bank partner. PADCO staff were quick to grasp the interest of Bertaud's work, and proudly presented the "PADCO/Bertaud model" to the planning community. PADCO motivation was simple and clear: "*it can be a significant time-saver in formulating feasible settlement*

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[1] Marie-Agnes Bertaud is credited by her husband Alain and other model users as the driving force behind the computer upgrading of sucessive versions of the model. She is a co-author on most of Alain Bertaud's model documentation, and the first author of a few technical and analytical articles about the model and its use [Bert 85] [Bert 88].

projects" within a context of "*rapid urban population growth, increasing complexity and level of investments and the short time frame in which to make important decisions* [PADC 81]."

In Thailand, Alain Bertaud worked for the National Housing Authority (NHA), who became interested enough to fund part of the model programming, particularly the component handling alternative site layouts. Apparently, it was in meetings with Alain Bertaud sitting on the Thai side of the table, that World Bank staff took first serious notice of the model. In 1977, the WB commissioned CITRUD in cooperation with PADCO, to develop the Bertaud model further. A report was presented in 1978, co-authored by Alain and Marie-Agnes Bertaud, and James Wright [Bert 78].

The World Bank, a product of the Bretton Woods conference (1944), had initiated a program of urban lending in 1972, at the request of member governments. This was the McNamara era (WB president from 68 to 81), marked by a policy of "targeting the poor". Legend has it that this policy started after Robert McNamara's first visit to Calcutta, where he was moved to tears by what he saw...(If the legend is well founded, one may ask what took him so long ?). I wish it was that simple to turn the winds of history; I suspect that the acknowledged implications of the urban explosion and the lessons from the Marshall plan's success, meaning, "*concessional money was not necessarily wasted money* [Econ 88]", helped a little bit in his conversion. In any event, under Mr. McNamara the WB consolidated its on-going shift from being a reconstruction bank, directed to Europe, to a development lender, targeting the third world.

So between 1972 and 1982, the Bank lent "*more than $2 billion to some thirty-six governments, financing sixty-two urban projects* [Cohe 83]", many of them in low-income housing. In the process, the WB acquired its own motivation to do research on the "*development of analytical tools to facilitate the costing of alternative designs and to establish layouts that minimize overall costs*", explains Anthony Churchill, then Director of WB's Urban Development Department [Herb 81]. The magic word was <u>affordability</u>, because it led to real <u>cost recovery</u>, which in turn led to the key objective of <u>project replicability</u>. The poor performance (or outright failure) of many of the early projects was attributed to exaggerated costs -- compared with what the beneficiaries could afford paying --, that quickly exhausted the financing capabilities of public institutions to subsidize housing for low-income families. Sites-and-services projects (providing "only" land and basic infrastructure, leaving the construction of the housing units open to a greater variety of timing and alternatives) became fashionable as a better solution. The idea that you could minimize costs through tracing the relationships between plot sizes, variations in plot shapes and layouts, and costs of provision of roads, utilities, etc., became very attractive. The Bertaud model was therefore very opportune for the WB new agenda.

We can thus say that, besides the remarkable ingenuity of the author and his collaborators, the model was also in a way a product of the emerging sites-and-services policy -- just as it was enabled by the new technology that produced programmable pocket calculators.

From this point on, the fast pace of technological developments and the changes in the low-income housing scenery helped to produce a series of different versions of the Bertaud model. In Table 1 is a brief summary of the main versions. We will look into the core equations of the first programmable version, and then proceed to analyze the overall use made of the model and the impact it had, before considering the details of the history of the model.

1970	1976	1982	1992
Freehand equations, graph curves [slide rule]	1st version, 5 sub programs [Calculator]	Two sub-models: Affordability [spreadsheet] and Land Use and Infrastructure Costing and Design (Code-85, Code-PC) [graphics]	Private Developer Assistance model [modular spreadsheet]

Table 1 - Main versions of the Bertaud model

The model.

The first programmed version of the model (1976) was made up of five parts or sub models:

I For analyzing the relationships among the basic variables in housing projects (supposes a simple grid-like layout). This sub model contains the basic equations;

II For analyzing the variables which affect circulation space and the cost of on-site infrastructure, with more flexible layouts;

III For analyzing the impact of differential land pricing;

IV For analyzing the impact of graduated monthly loan payments, considering increases in beneficiaries' incomes;

V For identifying the subsidies implied by each settlement design option, and the respective implied cash flow.

The core of the model (program I) has a simple structure. Affordable monthly payments and mortgage terms are used to calculate the capital available on one side of the model, while the costs of infrastructure, on-plot structures and the public facilities provided, determine the capital needs on the other. The link between the two sides is provided by population density, since the total capital to be equated will be defined by the number of households per hectare, using the individual household contribution from one side and the costs per plot from the other.

These are the basic equations:

	<u>Where:</u>
(1)	k = total capital investment per household
k= (10000*i*(e+c)/d)+a	i = number of people per household
	e = cost of land per square meter
(2)	c = cost of infrastructure per square meter
k=f/g	d = population density (number of people per hectare)
	a = total cost of superstructure per household, including
(3) f=g*((10000*i*(e+c)/d)+a)	connection costs
	f = monthly payment per household
(4)	g = capital recovery factor (monthly decimal fraction)
j=100*i*(100-m-p)/d	j = average plot size in square meters
	m = % of land used for open space and community facilities for
	which costs are recoverable
	p = % of land used for circulation

Table 2 - The basic equations of the Bertaud model

In fact, this program has three classes of variables: Financial, Design Standards and Project Layout. In a more elaborate version, published in 1981 [Herb 81], they were broken up for more detail in the following way:

<u>Financial variables</u>:

$$\frac{\text{Capital affordable per}}{\text{household}} = \frac{\text{Monthly payment}}{\text{Capital recovery factor}} + \text{Down payment}$$

(link variable: capital affordable per household)

<u>Design standards and unit costs:</u>

$$\frac{\text{Capital affordable per}}{\text{household}} = \frac{\text{Cost of land and infrastructure per hectare}}{\text{No. of households per hectare (density)}} + \frac{\text{On-plot development costs}}{\text{(superstructure)}}$$

(links: capital affordable per household, gross residential density [persons/hectare])

<u>Project layout variables:</u>

$$\frac{\text{Number of households}}{\text{per hectare}} = \frac{\text{10 000 - circulation space/ha(m2) - open space/ha(m2)}}{\text{plot size(m2) + additional space per plot for community facilities}}$$

(link variable: gross residential density)

In order to calculate more precise monthly payments, another three equations can be used, to solve for (1) varying circulation space according to plot size and type of layout; (2) length of network per square meter of landing according to plot size and type of network, and (3) infrastructure costs per square meter of land. The general idea is that once new values for unit cost and circulation space have been calculated, they can be plugged into the original equation to obtain a more precise estimation of implied monthly payment. This principle can be applied to other equations of the model, allowing for a variable degree of detail.

It is interesting that in one of the early publications, there is a reference to some criticism made of the model, which was probably at the origin of the effort to increase the model precision: *"One valid criticism of employing the basic equations of the model has been that in reality on-site infrastructure costs will vary with circulation area and the length of infrastructure networks when the plot sizes are changed. Since the basic equations use only average values (or those of a given plot size) for circulation and unit infrastructure cost there will consequently be some distortion in projecting monthly payments for a wide range of different plot sizes* [Erba 79]." The same author uses real data from four site plans to compare the results with the model projections. His findings are that "*an error of less than 10% can be maintained* " when using average values for circulation space and infrastructure cost per square meter.

In the version described in 1979 [Erba 79], the 5 subprograms used a total of 31 equations, and allowed for special cases such as walkup apartments. In a version published in 1981 [Herb 81], the same 5 subprograms use 39 equations. These variations may be in part a consequence of a desire to increase precision and scope, but mostly they reflect adjustments to facilitate the cumbersome programming of the electronic calculators, responding better to its built-in abilities and constraints. Later on, as we will see, new information technology advances - such as spreadsheet software - enabled further evolution of the model; but the same mathematical relationships remain at its core through all versions.

A more complete description of the model's equations and variables can be found in appendix 1, and in other references [Erba 79], [Herb 81], [Bert 85], [Carr 86].

Taken separately, many of these equations seem pretty simple. But the fact that they work together is not such a minor achievement, and it transforms them into a powerful planning aid tool. Cristovão Colombo's idea also seemed simple... after he made it work. "*The really genius idea behind the model* ...says Jerry Erbach (PADCO), is that "*Alain [Bertaud] tried to link together simple equations... you have all these really simple straight forward calculations, but nobody ever linked them together. If you want to calculate how many plots you have given a certain amount of circulation space and so on you can do that, it's a simple formula; but now that gives you a density that you can relate to cost and so on...what Alain did was to figure out how to do these calculations together* [Erba 92]." This simple, elegant ability to relate other parameters to cost is in itself a lever to change the site planning process, as we will see.

Despite this, the model's author never made big claims for himself. In fact, he was reluctant to publish. One of the reasons was that he felt there was a real danger of misusing the model; "*With the model you can produce pages and pages of impressive results that may be absolute garbage...if you don't use the right data, and if you don't realize its limitations* [Bert 92a]." The model could lend a certain "aura" of scientific authority in substitution of serious and careful field work. So when it was finally published (as a World Bank technical document), and with each update, Bertaud and his co-authors went to great lengths to explain the model's limitations. These can be summed as follows:

• The model is a trade-off model, not an optimization model. It does not necessarily produce optimal solutions for resource allocation;

• The model does not indicate whether solutions are functionally feasible on the real sites, culturally acceptable to local poor families, socially acceptable with respect to community health and sanitation, or financially sound in terms of subsidies;

• The model does not generate information on the demand for low-income housing, it is focused on analysis of supply and pricing;

• The model does not input all relevant constraints, for example, types of equipment available for infrastructure, fiscal rules on cash flow, etc.;

• The model does not deal with all crucial components of settlement programs, which must be considered before and after applying it.

Most of these disclaimers are more a kind of "no-nonsense check-list of the seasoned site planner", and not specific or exclusive to this model. The warning that it won't optimize solutions is almost modest. Because it involves site layout, and this class of problems is often one that is NP-Complete in nature, no model would be able to guarantee optimal solutions here for the good reason that there is almost never a unique "optimal" solution that is head and shoulder above all others: there may even exist a very large number of nearly as good (and very different) local maxima (or "plateaus"). But the warning serves well to emphasize that the usefulness of the model lies in studying trade-offs, asking what-if questions, and not in trying to obtain through it some archetype of "the good site design". *In fact*, says James Wright (WB), "*there is no technically correct answer. The important thing is to make a project affordable*". "*The model... is a tool to be used by planners who want to see the implications of different options* [Aust 86]."

For all practical purposes, the Bertaud model is a simulation model (or, more precisely, a "conditional forecasting" model, according to Greenberger's taxonomy [Gree 76]).

Uses and Users of the model.

Who uses the model? Early documentation presents it as targeted to *"technicians, administrators and policy makers who are responsible for low income settlement projects in developing areas* [Herb 81]." Among the technicians, it is intended in particular for planners, engineers and financial experts. Later on, the explicit range of users is enlarged and made more specific: *"Shelter Finance and Executing Agencies...Policy makers...Technical staff (planners, engineers, economists, community workers)...Beneficiaries...External Assistance Agencies* [Carr 86]."

How can they use it? Again, the early documentation presents a large scope of use, practically all phases of the project cycle: "*Policy discussions...Project identification...Project preparation...Project appraisal...Monitoring of implementation* [Herb 81], [PADC 81]." Within each project, the model is presented as being *"capable of analyzing the effects of changes"* in: site acquisition costs; site layout/land use characteristics; infrastructure standards and costs; shelter unit options and costs; financing terms for beneficiaries; timing of project expenditures and revenues; and developer's financing arrangements [Carr 86].

What happened in reality? In my research, I found some evidence of use all across the board, corresponding to the above expectations, but with different weight among various classes of users. Planners and engineers appear as the primary users, although the number of policy-makers, regulatory agencies, and project appraisal teams increased over time. There was a clear shift of the center of gravity of uses with time (from project formulation to policy discussion, from policy discussion to project appraisal). I also found examples of an interesting "new" kind of user, the private developer, bringing a different perspective in the way the model is used -- and one that may well become the primary focus in the near future.

In Tables 3 and 4 are enumerated, respectively, the <u>countries</u> where I found cases of application of the model, and the <u>users</u> I identified.

In Table 3, note the spread among the African, Asian and American continents - no European cases -, with a dominant representation of the African-Middle-East bloc (10 countries) and the Latin-American bloc (8 countries). The use of the model in China shows its applicability across social economic systems, and the fact that it was actively used in the USA[1] defies the temptation of labeling the model as dedicated only to developing countries.

As for Table 4, besides Alain Bertaud and the other planners I interviewed, note names such as James Wright and Stephen Mayo, co-authors of the most recent World Bank policy paper (with Michael Cohen, the principal author, and others [Cohe 91]), that have extensively used the model for policy analysis.

[1] One of the factors that promoted the use of the Bertaud model in the USA, was a Congress requirement that a housing project had to be affordable to below the median income of the population of the country, in order to have the housing guaranty loans approved. Carlos Linares tells how he "*accumulated an enormous amount of experience evaluating the housing projects that were presented by the government for funding under aid loans...and also recommending changes through analysis with [the Bertaud] model, so that these...affordability targets could be met* [Lina 92]."

We have seen so far the model and the highlights of its social, institutional and technological context. Next we will trace the history of use of the Bertaud model, beginning with the concerns and practice of its author.

Countries
Cameroon
China
Colombia
Dominican Republic
Egypt
El Salvador
Guatemala
Haiti
India
Indonesia
Jamaica
Jordan
Lebanon
Malaysia
Mauritius
Morocco
Nicaragua
Panama
Philippines
Somalia
Thailand
Togo
Tunisia
USA
Zimbabwe

Table 3 - Countries traced where the model was applied (Total: 25)

The poet Paul Valéry once said that "in truth there is no theory which is not a fragment...of an autobiography."[1] What moved Alain Bertaud? As a senior planner, he shared the institutional policy concerns of the time, and its respective agenda. But I found in him also an individual of strong social concerns, and very much the in-the-field, hands-on professional, with pragmatic concerns. That the model came in response to all these facets, is shown by his explicit goals [Bert 78], [Bert 84a], [Bert 92a], which I sum up this way:

• To help improve the dialog between planners, engineers, financiers and other technical staff from the beginning to the end of the planning process, avoiding the rigid and inflexible project design sequence;

• To explore less obvious trade-offs and design solutions, facilitating acceptance of lower standards as an alternative not implying lower quality of life;

• To improve conditions for community participation, putting a price tag on each site feature, in terms of its impact on affordability.

In the next section, we will look further at these goals, and at what happened in practice.

[1] Paul Valéry, Oeuvres, Editions Gallimard, Paris, 1965.

Name	City	Model Versions
Alain C. Bertaud	Washington	Affordability, House1, Code-85, Code-PC, Prog.Calculator, Nupsmo
Arsila Crema	Washington	Affordability
Arthur King	Kingston	Affordability, Code-85
Augusto Samaniego	Cuenca	Affordability, Code-PC
Carlos Caminos	Merida	Code-PC
Carlos Linares	Washington	Affordability, House1, Code-PC, Prog.Calculator
David Dowell	Oakland	Affordability, Code-PC
David Gilmore	Washington	Prog.Calculator
E. Steyn	Pretoria	Code-PC
Eduardo Prado	Panama	Affordability, Code-PC
Eligio Alvarado	Panama	Affordability, Code-PC
Esteban Rodriguez	Panama	Affordability, Code-PC
Evan R. Rottner	Washington	Affordability, Code-85, Code-PC, Prog.Calculator
Fermin A. La Rosa	Makati	Affordability, Code-PC
Foo Tuan Seik	Bangkok	Prog.Calculator, Code-PC
Francois Dost	Paris	Affordability, Code-PC
Frode Kvaerneng	Harare	Affordability, Code-PC
Garry Turnbull	Kingston	Affordability, Code-PC
Gary Jeffres	Kensington	Code-PC
Geoffrey K. Payne	Oxford	Affordability, Code-PC
Gerald Erbach	Washington	Affordability, Prog.Calculator, Code-PC, Private Developer Assistance
Graciela Pascual	Panama	Affordability, Code-PC
Gulab Bilimoria	Nasinu	Affordability, Code-PC
Heraldo Delgado	Panama	Affordability, Code-PC
Hercilia Urena	Panama	Affordability
Hugh Leroux	Paris	Affordability, Code-PC
Hugo Rosales	Panama	Affordability, Code-PC
Ir. A. R. Manuel	Rotterdam	Code-PC
J.B. Leonard	Edinburgh	Code-PC
James O. Wright, Jr.	Washington	Prog.Calculator, Affordability, Code-PC
Javier de Garcia	Panama	Affordability, Code-PC
John Herbert	Washington	Prog.Calculator
John Stover	Glastonbury	Code-PC
Jorge Vilas	Panama	Affordability, Code-PC
Judith Porcell	Panama	Affordability, Code-PC
Julian Luque	Panama	Affordability, Code-PC
Julian Velasco	Bogota	Modelo Juliana
Karl Weber	Bangkok	Prog.Calculator

Table 4 - Bertaud model users identified in this research (part I)

Bold = *interviewed*

Name	City	Model Versions
Larry Birch	Washington	Affordability, Code-PC
Lee Baker	Washington	Prog.Calculator
M.P. Morkel	Johannesburg	Affordability, Code-PC
Maria Hoek-Smit	Philadelfia	Affordability, Code-PC
Marie-Agnes Bertaud	Washington	Affordability, House1, Code-85, Code-PC, Prog.Calculator
Mark O'Connor	Kingston	Affordability, Code-85
Michael J. Enders	Washington	Affordability, Code-PC
Miguel Preciado	Panama	Affordability, Code-PC
Nandraj Patten	Port-Louis	Affordability, Nupsmo
Nasser M. Munjee	Bombay	Affordability
Nicolas You	Nairobi	Affordability
Noel Ellis	Kingston	Affordability, Code-PC
Nubia De Villalobos	Panama	Affordability, Code-PC
Peter Nientied	Rotterdam	Affordability, Code-PC
Philip W. Rourk	Washington	Code-PC
Pitticas Mieie	Paisley Renfrew	Affordability, Code-PC
Praksh Mathur	New Delhi	Affordability
Raquel Orozco de Espin	Panama	Affordability, Code-PC
Raul Bethancourt	Panama	Affordability, Code-PC
Raymond Archer	Bangkok	Prog.Calculator, Code-PC
Richard L. Ludwig	Seattle	Code-PC
Rivera Piza	Washington	Code-PC
Robert D. Daughters	Washington	Affordability, Code-PC
Robert Dubinsky	Christ Church	Affordability
Robert Pomeroy	Washington	Affordability, Code-PC
Roberto B. Moranchel	Washington	Affordability, Code-PC
Rodolfo Rendon	Quito	Code-PC
Romeo B. Ocampo	Manila	Code-PC
Samuel Noe	Cincinati	Affordability, Code-PC
Sandra Dutary	Panama	Affordability, Code-PC
Sanjay Arora	Bangkok	Code-PC
Setty Pendakur	Vancouver	Affordability, Code-PC
Shahid K. Hak	Karachi	Affordability
Steve Mayo	Washington	Affordability
Tom Russell	Boroko	Affordability, Code-PC
Trevor David	Christ Church	Affordability
Victor Amores	Panama	Affordability, Code-PC

Table 4 (cont.) - Bertaud model users identified in this research (part II)

(Total: 74)
Bold = *interviewed*
Main sources: WB data base (Bertaud), and field reports (see reference list at the end).

"We find that the modeler and especially the spokesman for the model are often far more important than the model itself in determining how and whether the model gets used."

Martin Greenberger, Mattthew Crenson, Brian Crissey [Gree 76]

Section 2: History of Use

Changing the site planning process; The fight against high standards; The fight against over-regulation; The ghost of community participation; The new roles of public and private sector, and the model mutation; Milestones in the history of model use, low-income housing policies, and information technology.

Changing the site planning process.

One of the most convincing arguments in favor of the Bertaud model's usefulness is the critique of the traditional "linear" design sequence for housing and other land development projects,[1] and, more to the point, the demonstration that planners were bound to such traditional design sequence largely by technological constraints -- until tools like the Bertaud model became available.

The bottom line of this argument is that planners had little opportunity to experiment and study the impact of different options before a project design was completed. The number of calculations and length of time required were prohibitive.

Instead, planners prepared a site plan based on existing standards, then gave it to the engineers, who planned the infrastructure; finally, the costs were calculated. This sequential process provided little opportunity for interaction between different specialists or for going back and changing the physical characteristics of the project after the initial design is produced. Experience shows that it is hard to introduce design changes once a commitment is made separately by each group of professionals. By the time the project reached the financial analysts, the costs were usually more than the target group could afford. Even if a few changes could be considered, it was too late or too expensive to look at other alternatives. As a result, such projects typically required heavy subsidies to make them affordable to low-income groups.

Let us look further into this traditional planning process, divided into 3 phases.

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[1] This critique is particularly well developed in a draft made by Bertaud in 1984 "*Efficiency in Land Use and Infrastructure Design*" [Bert 84a], later revised and extended in cooperation with Marie-Agnes Bertaud and James Wright [Bert 88].

The "planner phase." Alain Bertaud noticed that the typical project begins with a site being acquired by an institution with little consideration of how the land cost relates to the affordability of the project as a whole [Bert 84a]. Once the land is selected, planners prepare a site layout based on current norms and some knowledge of the targeted beneficiary group. It was found [Herb 81], [Carr 86], [Gake 87] that the training of planners does not lead them to determine the cost implications of the layout being prepared. Even if they could estimate the cost at this stage, it is too time-consuming, therefore expensive, to experiment with several different plans.

The "engineer phase." Once the layout has been prepared, it is turned over to engineers, who design the infrastructure, beginning with a cost estimation. This is a very time consuming task involving measurement from the drawings of everything to be constructed: streets, water systems, storm drainage, electrical networks, and so on. If the cost is too high, there is some margin for lowering some of the infrastructure standards (e.g., street surfacing, pipe widths), but not necessarily the changes with more impact. Also, this is usually met with resistance, beginning with the professionals themselves: "*the engineers also have this false idea, because they don't understand the economics very well, they say, well if we spent a lot of money right now it's better than spend it later; now it will be spent, and then with inflation it will cost more later; this of course is absurd if the people have no use for it* [Bert 92a]." Moreover, larger cost savings could be achieved through site layout changes, but it is usually too late at this stage to go back and modify the layout significantly.

The "financier phase." It is not unusual for the executing agency's financial analysts to have no contact with a proposed project until after the engineers have finished their work. Often, the project executing agency is responsible for fixing unit prices and financial terms; but by then the actual costs may already exceed what poor families can afford to pay. If the agency is unable or unwilling to revise the project from scratch, the only option left is either to subsidize the project in order to serve the targeted low-income group, or to sell units to higher income families. In these circumstances, it is common to find projects with subsidized interest rates and prices that do not recover the full cost.

In 1986, Austin tell us in "The Urban Edge" that *"many shelters projects still are planned this way...*[Aust 86]."

This effect -- missing the target (poor families) -- is generally recognized in parallel studies evaluating housing policies (by parallel I mean studies not concerned with the use of the Bertaud model). *"It is common to find"*, says Peter Ward, *"that units in housing projects, ostensibly constructed for the poor, have been bought-up by lower-middle-income families whose demands* *for housing are also unmet by either the private or public sectors* [Ward *]." As we already saw, this issue was central to the major policy shift towards "Sites and Services". It is reasonable to conclude now that, at least in part, this failure can be attributed to the constraints of the traditional planning process.

What changes to the traditional planning process are brought about by the use of the Bertaud model? By simulating project modifications, each time looking at the cost effects, a planner can develop a set of design targets that will make the project affordable. The planner can also discuss it on the spot with the other technicians: the iteration "planners -> engineers -> financiers" can now be done, or repeatedly simulated, quickly enough to allow for multiple alternative analysis. The Bertaud model "*makes it possible to identify very cost-effectively the key physical and financial cost characteristics of a wide variety of physical design alternatives for a low-income settlement* [Bert 85c]."

Thus, with the model, came the proposal of a new planning process; "*A...revised work sequence for land development schemes* [Bert 88]." In Table 5 is a summary of the phases in low-income housing projects, using the model:

PHASE I -	*PRELIMINARY COSTING, LAND USE AND AFFORDABILITY* a. Policy and standards data required to run the sub-model b. Market data required to run the sub-model c. Preliminary affordability d. Site selection
PHASE II -	*ANALYSIS OF THE PROPOSED SITE* a. Identification of the main features of the site b. Preliminary design of trunk infrastructure c. Design of price zones d. Revision of affordability table
PHASE III -	*DESIGN OF SAMPLE MODULES*
PHASE IV -	*INTERMEDIATE COSTING, PRICING AND AFFORDABILITY*
PHASE V -	*DETAILED SITE DESIGN*
PHASE VI -	*FINAL COSTING, PRICING AND AFFORDABILITY* a. Adjustment of the affordability table b. Project phasing - cash flow during construction c. Affordability, total project cost final adjustment

Table 5 - Phases in low-income housing projects, using the model [Bert 88]

The general idea is that one can use the model several times, from the early stages to the later stages, in a series of iterations, providing successive refinements in the model output. Tables 6 and 7 (next two pages) provide a sample of one of these steps.

In Table 6 is the data required as input to the affordability model, as well as the dependent variables calculated (spreadsheet version). Note the organization of the data in 4 major groups: land and development costs, land use characterization, pricing of residential plots, and cost recovery. This data structure facilitates the visualization of the impact of changes of project parameters in the overall affordability of the project; the Cost recovery section is in fact a threshold indicator for the "break-even" point.

Table 7 gives an example of a preliminary affordability study, in this case for a total of 694 plots of 6 different types [Herb 81]. The output values are in capitals. Note that this ease of considering a varying number of plot types (absent types are simply filled in with zeros) is an improvement on the calculator version, where these changes would be less transparent.

Did the model succeed in changing the planning process? There are multiple signs that the model has had, in fact, a significant impact; among them, the sheer number of projects that applied or are still applying the model[1], in the ways prescribed by it.

This is also the conviction of all the model users I interviewed. Drawing from his extensive experience in applying the model, Evan Rotner (senior economist in the Infrastructure Division of the WB) tells us that "... *the tool stimulates this iterative analysis at an early stage, because it allows you to do the iterations and simulate the different options on paper instead of having to go and draw something up and then take off of that engineering and costs and other parameters, and then working it out by hand and then saying the bottom line is that this doesn't work. After 5 days of work you discover one more option that doesn't work; so [instead] you could simulate with the computer tool different layouts, different plans, different costs, different mixes of beneficiaries, different prices, mixes of pricing structures, using agreed targeted affordability* [Rotn 92]."

Alain Bertaud noticed also that having the cost implications of each design and engineering option measured in terms of the affordability scale (more or less x dollars per month per family), made changes easier to accept by the other professionals, than when the cost was only viewed

[1] I identified 34 projects between 1980 and 1992, some of them targeting more than one hundred thousand housing units. References to these projects are included in Table 8 at the end of this section.

globally (more or less x million dollars per site). This is a very interesting issue; the model generated what amounts to a common reference basis between different value or belief systems. The importance of creating such a common reference is usually underestimated, because the differences between each profession's value system are not always obvious. Even at the risk of oversimplification, it is useful to observe that, for a civil engineer, a good road is a road that allows one to go fast from A to B ; for a social worker, it may well be a road that invites one to stop and interact with people as much as possible between A and B. For a planner, a street corner is an opportunity; for a traffic engineer, a curse. The Bertaud model facilitates a otherwise difficult dialog.

However, as we already saw, by 1986 there was a perception that too many projects were still going along the traditional lines. Why was the model not used more, given its obvious strengths, and its influential sponsors?

The answer seems to be a mix of a) institutional inertia and individual resistance to the pervasive invasion of computer technology in old, acquired, familiar process routines, b) limited access by the housing agencies in developing countries to the new technology, c) relative complexity and "unfriendliness" of the new technology, and d) persistence of traditional training of the professionals involved. Here are some pieces of evidence presented by the planners themselves:

<u>a) on the institutional and individual resistance:</u> "*...when we [WB] did Bombay urban, we actually brought an HP desktop into the field in Bombay, ran the models, there were a couple of guys there smart enough to understand what we were doing on the computer, more or less sat in a chair along with us while we were trying different examples of different iterations of model site plan. The implementing agencies themselves were way behind that, they were still operating in the traditional fashion. In Madras II , the Bank staff was not using the model either, because the staff were not the kind of people that were model oriented, particularly the planner, on that , was hostile to modeling, they just [went on] doing it by hand.* [Rotn 92]"

<u>b) on the limited spread of its support technology:</u> *"For example in Madras I [India], when the model was first used [by the WB], there was no computers at all, for example [at] the development authority or the housing boards, which were essentially using the model; the Bank staff was using the model for planning purposes, but the results were given to the implementation agencies and the coordinating agencies, they didn't have the capacity to do this stuff on the computer themselves. That was up to 2 or 3 years ago. There might be one computer (mini-computer) in the agency, air conditioned room, only the computer priests had access to it. What*

they were doing was hand versions of the methodology of [the] Bertaud model; Madras II, several sites, used Bertaud methodology, but it was done by hand [Rotn 92]."

<u>c) on the relative "unfriendliness" of the technology available:</u> "*The graphs were pretty powerful at the beginning, nothing like this had been done before, and you could very quickly see, OK what would you like, and very simply point out what was going on. The [model on the] calculator was good for the guys that were using the calculator, but a little bit mysterious for anyone else to figure out* [Erba 92]." "*My conclusion was, after seeing the results of the CODE-PC [Bertaud model], that it was still too cumbersome a technology, to be used easily by us, anyway* [Daug 92]."

<u>d) on the limitations inherent to professional's traditional training:</u> *"I [Carlos Linares] was able to make full use and appreciation of the model, because I came from a planning background. I had, with a pencil and eraser in hand, tried to design projects, I knew about design criteria, and I also knew that we architects and physical planners who design these projects, understand very little about finance, understand very little about the things that determine price, as opposed to just cost. Using the Bertaud model helped me to look at that aspect of housing development, the aspect that the developer looks at; the cash flow component, for instance, of housing development is something that physical planners have no idea [about], even when they graduate from university. There is just not a sense that housing is in fact feasible because there is a cash flow, not because it is a pretty picture, and we have focused so much on that pretty picture that we forget that what we see out there in the world that has been built, is built because some kind of feasibility and some kind of affordability criteria has been met, and so many of those have failed because those have been not met -- and other reasons as well, but those [financial considerations] are the determining factors about whether something goes through and whether something helps solve the housing problem or not* [Lina 92]."

And what about negative impacts? Did Bertaud's fears of model misuse materialize? As early as 1973, the same kind of fears were voiced by Schumacher:

> "Once you have a formula and an electronic computer, there is an awful temptation to squeeze the lemon until it is dry and to present a picture of the future which through its very precision and verisimilitude carries conviction...The person who makes the forecasts may still have a precise appreciation of the assumptions on which they are based. But the person who uses the forecasts may have no idea at all that the whole edifice, as is often the case, stands and falls with one single, unverifiable assumption. He is impressed by the thoroughness of the job done...If the forecasts were presented...on the back of an envelope, he would have a much better chance of appreciating their tenuous character." [Schu 73]

I found reference to at least two cases, one in Latin America, the other in Morocco, where it seems the model was put to use in some erroneous fashion. My sources were reluctant, however, to be more explicit about it. But, in general, the model users seem well aware of its limitations, and we can say that the model was more underused than overused.

Notwithstanding, these limitations only serve to emphasize the considerable impact of the Bertaud model in the housing planning practice.

The fight against high standards.

We saw already that the model had some use in helping the acceptance of lower standards, by facilitating the dialog among different professionals, and putting a price tag on each project feature. Now, we will look into the same fight, this time at an institutional level.

Planning standards came to existence having noble goals in mind, such as the public good in general, and rational use of land in particular. They are supposed to provide safe and sanitary conditions for residents, space for circulation and public facilities, and to protect the environment. In an ideal world, the higher the standards the better; but in the real world, high standards are expensive, and housing built according to high standards cannot be afforded by the poor. Unrealistic standards only cause more low-income settlements to be built illegally, with much lower standards and frequent disregard for the mentioned goals. By introducing his model, Bertaud sought to demonstrate that a) lower standards may be more adequate, and not affect the housing quality; b) considering the standards all together, instead of individually, allows for trade-offs and the choice of an adequate overall affordable package; c) accepting planned, well-thought lower standards can generate affordable low-income housing of higher quality than the uncontrolled, illegal construction exacerbated by the imposition of higher standards.

There are typically three types of standards dealt with by urban regulations: land use standards, infrastructure standards and building standards.

<u>Land use standards</u> regulate the way land is subdivided (road right of ways, densities, etc.) and the activities applying to it (residential, commercial or industrial uses, etc.).

<u>Infrastructure standards</u> set the levels of services, types of materials and construction details. They follow usually technical specifications defined by engineers.

Building standards stipulate materials suitable for use, as well as proper design, construction practices and details for sanitary and electrical installations.

At first sight, standards seem to derive mainly from technical considerations. In fact, standards are an institutional and policy issue. The reason is simple; they are more dependent on policies and politics than on technical factors. "*Appropriate standards have been discussed so far mostly as a technology problem...we argue that it is mostly an institutional problem* [Gake 87]. ". As a consequence of this institutional nature, the battle for affordable standards cannot be fought exclusively on technical grounds.

Why are there such high, unaffordable standards in practice? The most simple explanation is self-interest on the part of politicians, contractors, and others responsible for system maintenance -- not to speak of the beneficiaries themselves. But sometimes the situation is less transparent.

I found several examples of vested interests caused by an intricate web of institutional processes. For instance, in Malaysia [Bert 88], because federal grants for road construction are available if the roads are at least 30 feet wide, local agencies have no interest in lowering road standards; they also have an interest in reducing maintenance costs with higher standards, because federal grants pay for the road construction, but not for maintenance.

How does the Bertaud model help in this situation? The model can show the consequences of these standards very quickly, claims Alain Bertaud: "*It can show the maximum plot size that is affordable, given the low payment capacity of the target group and the expensive land use and construction standards which must be provided. Alternatively, it can show the high monthly payment that would have to be charged if the standards are maintained. If housing built under the official standards is not affordable, the model can be used to illustrate alternative types of projects that could be designed with more affordable mixes of standards.* [Bert 88]."

Plot size is just one among the many trade-off factors considered in low-income housing. The Bertaud model has been used to study the average infrastructure cost vs. number of plots; plot value vs. number of plots; infrastructure costs and plot value vs. plot frontage; infrastructure costs vs. streets width; differential land pricing and design efficiency; and location of open spaces and community facilities and design efficiency. A graphical expression of these trade-offs can be seen in Fig. 1 to 6 [Bert 88].

In Fig. 1 (average infrastructure cost vs. number of plots), note that increasing the number of B type plots from 1 to 4 reflects in higher average infrastructure costs, resulting from more space dedicated to circulation; then, as the number of B plots increase, there is a net decrease of the average infrastructure costs, because the increase in circulation space is gradually offset by the number of plots served. But this relation is not the only to be considered; in Fig. 2 (plot value vs. number of plots), we can see that, as the number of B plots continue to increase, there is a point where the market value of these plots decrease significantly. This is due, for instance, to the perception of narrowness of the street, which may give a feeling of overcrowding; the exact profile of the curve will reflect cultural factors and individual tastes.

In Fig. 3 (infrastructure costs and plot value vs. plot frontage) we can see another example of the importance of the distinction between cost and value. Decreasing plot frontage allows for less infrastructure costs (for instance, smaller water pipes lengths per plot), but in the extreme there is a loss of design efficiency (for instance, plot too narrow to allow two rooms with independent access).

Fig. 4 (differential land pricing and design efficiency) shows how different designs affect the different plot values, by means of exploring different levels of standards. For example, a different design may increase the number of plots served by wider roads, increasing the overall value and allowing for differential pricing and cross-subsidies.

Fig. 5 (variations in design efficiency for alternative community facilities locations), show how a better design can increase the number of higher valued plots, without lowering the standards in terms of percentage of area dedicated to open spaces and community facilities.

Finally, in Fig. 6 (Module design, sensitivity analysis), we have an example of how the model can be used to study which design parameters will most affect the overall cost.

What role played the model in the institutional debate on standards? The model was used, for instance, in Uttar Pradesh, India [Bert 88], to analyze the impact of standards. It was found that 87 % of the urban households in the state would not be able to afford the minimum sized plot in a land development which meets all the land development and municipal engineering regulations. Similar studies were conducted, among other places, in Serpong, Indonesia; Quetzaltenango, Guatemala; Mogadishu, Somalia [Bert 89] [Hann 89] [Olse 85] [Temp 80]. Table 8 (at the end of this section) contains several examples of projects where the model was relevant in showing that required standards were inappropriate.

The fight against over-regulation.

Since standards are set in regulations, and these usually are derived from legislation, the fight against high standards spilled into a more global fight to reform regulation. The focus was often on the excess found in the number of rules and regulations, many times set by different agencies and institutions, with no consideration for the overall effect.

Why this tendency to over-regulation? Malpezzi tell us that

> "The tendency to over-regulate can be explained by (1), the failure to consider costs and benefits, from which follows (2), the fact that every interested party adds their own small regulations and that the regulations are never considered together (the adding up problems), (3) some over-regulation results from a breakdown in exchange between regulators and the regulated (the Coase theorem can be applied here), and (4) regulations are an opportunity for rent seeking behavior/vested interests. Given such over-regulation, understanding reduced efficiency is easy: regulations impose larger transactions costs than benefits. Inequities also follow: the poor are not particularly good at rent seeking behavior, and since regulations raise costs and restrict supply, it is the poor that are rationed out first. Regulations on lot size, for example, are not directly binding on the rich." [Malp *]

Besides the vested interests that Malpezzi refers to, I found traces of other sources of over-regulation: simple inertia in keeping outdated legislation, made obsolete by technological developments, and inadequate legislation inherited from the colonial times, transplanted from the former imperial metropolis with little regard for local context ([Bert 89] [Dowa 90]) .

The problem was felt, first of all, by actors in the housing scene that didn't have the leverage of the World Bank to obtain regulatory exemptions. A good example is the experience suffered by the IDB (InterAmerican Development Bank) in 1983, Bogota. The IDB sponsored a housing project which applied the calculator version of the Bertaud model known locally as "Modelo Juliana"[1], and "*came up with the final design which was modified after approval of the project because it turns out that there was some ... city wide regulations, that impeded us to work with such a small frontage of plot, so we ended up having to expand the frontage...to 6 meters [from 4]. So that was the minimum frontage that we ended up, [because] for some reason that I was furious about afterwards, none of the local counterpart chain ... informed us of [those regulations] that ended up having to require complete revision and redesign of the subdivision. It was simply municipal legislation* [Daug 92]."

In some cases, like with the IDB in Bogota, the friction caused by over-regulation was enough to discourage some actors to further use the Bertaud model, and to redefine both their strategy and

[1] Named after Juliana, a young daughter of the head of the local consultant firm. IDB staff kidded the local consultants in Bogota for "pirating" the Bertaud model, while they kept insisting that they hadn't "pirated" anything. Note that Alain Bertaud never imposed any constraint on the free copy and use of the model.

their role in housing projects: "*the infrastructure standards...[is what] the Bertaud model tries to play with, and yet in fact we are finding in Latin America that standards are not as easy to manipulate. ... We used to work in a much more idealistic world ten years ago, we could work in a tabula rasa, everything could be modified; but we are finding that these countries are much more reluctant to lower their standards, for political reasons, than one would think, even if it means having to pay higher subsidies and things like that; so you find that the margin that you have to play with is relatively small* [Daug 92]." For a while, the IDB tried to focus in changing regulations in developing countries: "*in Trinidad we got them to reduce the minimum size lot regulation which was 5000 sq. feet to 3000 sq. feet.* [Daug 92]"; but soon it was their self-defined role that changed. *"Our major concern right now is more with demand, proper fit between demand and the product that it's being offered, than it is to try to reach cost minimization...What we want to do is define the ceilings within which the private sector has to supply housing, and our assumption is that the private sector is going to do the optimizing, and it is not necessary for us to worry that much about it* [Daug 92]."

The World Bank, with greater political leverage, usually requested (and obtained) special zoning and other regulation exemptions: "*All the sites and services we [WB] did in Utapradesh and Mayapradesh were illegal, in terms of standards* [Bert 92a]." But the overall effect was that, after the WB left the scene, efforts to replicate the projects failed, at least in part because the new projects had to deal with the legislation in vigor.

Although by 1985 there was already a concern that the housing projects were not as replicable as thought, the point that planners were trying to make was that decent design was affordable, if lower standards were allowed. This point was made; what was not clear at that time was that a project should be replicable in the sense that a government institution, which has a monopoly on low income housing, is able to replicate a similar kind of project within the country. It was later found that was not the case.

In consequence of this replicability issue, the World Bank started to shift its strategy of funding by acting more through mortgage institutions and by reforming the financing sector, rather than by directing its attentions directly to housing. The WB became also more concerned about efficiency of cities, rather than concentrating its efforts on the subsector of poverty. For instance, when the WB was doing large sites-and-services projects it often had the problem of linkage with the rest of the infrastructure. They would finance a little piece of a pipeline to bring water or they would increase the capacity of a sewage plant in order to handle the sites-and-services project, only to conclude that by doing that they had in fact now two services that were badly run - for the whole city, not only for the poor.

The Bank got more and more involved in the overall management of the city, in the infrastructure of the city, and found that it was a mistake to try to improve a little geographical area (low-income area), when in reality even the middle income area, or even the high income area, were very badly run; "*you have to improve the service of the whole city, and be careful about the poor and direct maybe more resources to them, but you cannot have a little enclave of efficiency just for the poor, if the middle class is suffering from bad infrastructure* [Bert 92]." This became the general line of reasoning.

Inevitably, an important part of this "city-wide reform" policy focused on land use legislation. In at least a few cases, the Bertaud model provided the ammunition; a good example is the analysis of Seoul's legislation about the way land is transformed. In order to use the land you have to go through a number of regulations and laws which tell you how much you can use, each time. But there are 5 levels of this legislation, most of them completely arbitrary. A [Bertaud] model based analysis showed that in consequence, from a total of 75 square km, only 23% of floor space could be built legally.

The Bertaud model definitely played a role in this fight for regulation reform. It is interesting to note that instead of entering in decline by loosing users (like the IDB) in face of institutional obstacles, the model simply found a new focus of use, helping to overcome the very same institutional obstacles. Articles by James Wright, David Dowall, Lawrence Hannah, Marie-Agnes Bertaud and others (besides the model author himself) make explicit mention of the use of the model in their analysis of the impact of regulations in the housing sector[1], along the lines of the Seoul example.

The ghost of community participation.

One of the areas where the model appears to have no impact at all is on the participation in the process by the community / beneficiaries.

Bertaud clearly intended to stimulate and facilitate community participation in the settlement projects. Practically all of the housing policy papers in the last decade, from the World Bank and UNDP to local governmental agencies, hail this participation as desirable and useful. Yet, I found almost no traces of such participation (in projects using the Bertaud model), among all the field reports I went through. And the exceptions are more a kind of anedoctal evidence, like the case of

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[1] [Bert 89] [Dowa 90] [Hann 89] [Olse 85] [Wrig 84]

one African country that implemented the expressed planner's wish of dialog with the beneficiaries by sending a machine-gun platoon along with the planners to "facilitate" the dialog.

One aspect of it is that it is harder to have any dialog with future beneficiaries in sites-and-services projects, than in the case of slum upgrading: in one case, the "clients" are already there, in the other case, it is a more undefined population. Does this mean that sites-and-services projects were more frequent than slum upgrading? It doesn't look like it. *"To my knowledge"*, says Alain Bertaud, *"we never did a sites and services without doing also slum upgrading, it was a two prong operation"*[Bert 92a]."

So with respect to dialog with beneficiaries, the Bertaud model is even more adequate for slum upgrading types of projects than for sites-and-services. Then why is it not used for that purpose? One explanation is that the base for discussing alternatives, particularly in the engineering component, is seen by staff as essentially of technical nature -- therefore, with little room for non-professional opinions. *"The advantage in slum upgrading, "* says Bertaud of his model, *"is of course that you could use it for dialog with the community, I've always advocated that...Normally when you have a slum upgrading, it's even more transparent, because the government will say 'we are going to subsidize', lets say, for instance in India, '500 rupee per family and anything additional you have to pay it yourself'; so with the model you can run it very easily, you have up front 500 rupees, and if the people say 'we want individual water supply', you can right away say it will cost you 3 rupees a month for repaying the loan, and 2 rupees of water bills. Then they say, 'maybe we can share a tap for 3 people', then we can say right away, this, of course will affect the capital costs, the repayment, so you give immediately a [price tag], that way you can reach something that it is acceptable. So it is very effective. Unfortunately, again, this is the ideal situation. Slum upgrading, especially in India, is usually done by engineers, who see that more as an engineer thing, and they will try to force the solution they want...*[Bert 92a]."

But not only engineers are at fault regarding lack of motivation for dialog with the community of beneficiaries. For instance, in one of the low-income housing projects in Latin America using the Bertaud model, I found a rule stipulating that any family that had in the past illegally occupied land under the jurisdiction of the project Institution, was not eligible for the new settlement. As a mechanism to stimulate dialog with squatter communities, one can hardly find better than that...

In many cases, the local institutions or agencies are themselves reluctant to "mess-up" the control of the project process with too much public participation. In some instances, like the last example, there is the fear of encouraging more illegal settlements. In other instances, this may be because of multiple, different interests among beneficiaries, making potential conflicts seem easier to solve if distance is kept by means of using technical "priesthood" authority. Yet in other instances, there are special interests that are not transparent; like the case of a Palestinian settlement, where the official country negotiator with the WB explained privately that they didn't want roads less than 9 meters wide (which the WB staff found clearly exaggerated), because this was the width needed for military tanks to circulate and maneuver. The Bertaud model does not account for implicit project design constraints of the type: " With Palestinians you never know when you need to send in the tanks..."

Similar findings are reported by Ralph Gakenheimer and Carlos Henriques Brando:

> "It is possible for infrastructure to become an issue of community participation - and it has been in certain upgrading projects. Significant participation is rare, however, for at least two reasons: 1) the active government agencies and private firms are likely to be conservatively oriented and to find management of meaningful participation difficult; 2) given the infrastructure configuration surrounding the site of intended extension, there are likely to be few meaningful choices in the hands of the community [Gake 87]."

So it seems that institutional ill will, or lack of will, is more determinant in this deficit of community participation than the availability of the model, or the nature of the model's technological expression. But, in my view, this doesn't minimize the importance that the accessibility or "friendliness" of the model's technological base has to non-professional users. Keep in mind Erbach's reference to the calculator as "*mysterious for anyone else*" except the one that is using it; because there may be another side to this issue to be considered. On the next two pages are samples of the programming sheets for the electronic calculators. The manuals speak of "easy 54 steps", but the samples speak for themselves of the tedious, cumbersome operation that it represented to use those calculators.

In this research, I restricted myself to the instances of use of the Bertaud model. But in other cases (that I know of) where there was a significant community participation, there is a "bottom-up" pattern that emerges: the housing projects were initiated by slum dwellers associations or through other non-governmental organizations. Could it be that the Bertaud model's institutional "upbringing", strongly associated with the WB, limited somehow its spread of use among community activists? Or is there a bigger technological gap in accessibility, regarding the model use, compared with the more technological "milieu" of institutional staff? If that is the case, can we improve in a significant way the community participation, if we **a)** put in practice a deliberate effort to disseminate (including training) the Bertaud model among community activists, **b)** produce a model version with a customized user interface for community activists? Field research and a thorough account of the community participation in low-income housing projects may find some interesting answers to these questions.

The new roles of public and private sector, and the model mutation

While the model did not succeed in attracting community users, it acquired an "unexpected" client: the private developer.

Until very recently, shelter for the poor was considered an exclusive concern of the public sector. International donors and development banks acted accordingly: "*We automatically did all our programs through government agencies and we never questioned that...We took it for granted that there was nothing wrong in working with housing ministries and housing institutions* [Daug 92]." The private sector had no apparent motivation to invest in low-income housing: low profit margins, high risk, too many regulations. So it came as surprise for Marie-Agnes Bertaud to find, in 1986, a private developer among the most interested and active people in learning the Bertaud model, when she was in Panama training people from the ministry of housing (IDB project): "*We found it interesting but we weren't really quite sure how to deal with it* [Daug 92]."

With the housing policy shifts towards a city-wide approach, acting more through institutional and legislation reform, the role of the private sector became inevitably the focus of attention. Robert Daughter acknowledges how the IDB, "*like the WB, is as of the last year or two actively moving towards privatizing housing delivery...which is part of this defining of the role of the Government as enabler, not provider, which is now well diffused here in the International circles* [Daug 92]."

Private consultants firms working for those international donors and development banks, like PADCO, were quicker to grasp the change of winds. During an assignment in Casablanca, Morocco, for the CIH (Credit Imobilier et Hotelier), PADCO undertook the task of adapting the Bertaud model to the perspective of private developers. It is important to note that, at that time (1985), the model was already implemented in spreadsheet software (Visicalc), which made changes and adaptations much easier than with the pocket calculator (it is not by chance that no major variations of the model were done before the spreadsheet software was developed). Jerry Erbach describes the outcome of this effort:

> "It was divided in a master program, which resembles the Bertaud model very much, and then there was a program for the financing of the project, the cash flow, how the developer could arrange his financing to reduce the amount of level of financing he needed from the Bank to do the project and therefore to cut the cost; there was a site development element, how you could reduce the cost of development of the site in order to do that, and then there was the [housing] unit itself, how you could play with the unit to reduce cost [Erba 92]."

The rationale behind Erbach's approach was that the developer has two things that he can play with, trying to keep the cost down: one is the size of the housing unit -- under certain limits beyond which he won't go, because he probably figures he won't be able to market the unit -- and the other one is the finishings.

Another aspect that made the Bertaud model interesting for the private developer, was precisely the ability to demonstrate the impact of regulations on the overall cost. Erbach, Bertaud and Linares mentioned two different ways in which developers made use of this ability: to help their lobbying for deregulation, and to evaluate the profit margins, rates of return, when complying with all the regulation - and therefore to help to decide whether to take or refuse a project. In Jordan, for instance, the USAID, PADCO and the Jordan Housing Bank organized a "Private developer competition", in which the developers used the Bertaud model to justify their requests for regulation and zoning exemptions [Erba 92].

All this seems to vindicate Daughters' opinion that "*a way to reactivate the Bertaud Model, and its relevance, would be to disseminate this technology not to the public sector anymore but to the private sector* [Daug 92]." PADCO's Erbach is doing precisely that, using the new modular spreadsheet software to expand the Bertaud model into an elaborate "Private Developer Assistance" model.

But does this mean the end of the use of the Bertaud model in the public sector? My findings point to the contrary. The model is alive and well in the very same major development institutions: the WB and national housing agencies. What changed - again - is the way it is used.

With the new housing policy, the WB started a new approach: program loans, instead of project loans. Program loans cover a sequence of projects in different sites; it deals with a much larger scale, in volume and in time. The implication is that now a project, in order to get funded, has to be a part of a larger plan. This is another way to say that either a project is going to "replicate" or it won't be even considered.

At the same time, the Bank removes itself from the project details; instead, it assumes the role of project appraisal and control. The appraisal relies in great part on the use of the Bertaud model by both the Bank and the local housing institutions in charge of the project. Evan Rotner, at the head of several WB program loans, goes further: in his view, the practice of program loans wouldn't be possible at all without a tool such as the Bertaud model. "*I would say that it is only* *because of the availability of this tool, as a management tool, that we were able to do a program loan of this type, successfully, for the first time; otherwise the supervision and the appraisal of this stuff would have been a nightmare* [Rotn 92]."

How did it work? For instance, in Bombay Urban, the WB appraised a project that was supposed to deliver 100 000 households or plots for development in possibly 20 sites. Since they couldn't possibly appraise the whole loans, what they did was to appraise a couple of model sites, about of 5 or 6 thousand plots, with different layouts in different locations, using the Bertaud model. This way it was established a) what an acceptable layout would be; b) the target objectives in terms of percentage of low, middle and high income beneficiaries; c) physical and engineering standards.

Having reached an agreement regarding all major parameters, the WB then said "*OK, now, we've done it for 5 or 6 thousand plots, now you have to do it for 100 thousand plots, on a rolling basis, do feasibility studies, using the same objectives and meeting the same design criteria ... therefore it has to be all done on a computer; because we don't want to have to wait, we want to have something for which the methodology, the objectives and the analysis is standardized, so we don't have to go through a pile of paper that high to see whether there is a consistent logic running through the analysis* [Rotn 92]."

The same principles - including the use of the Bertaud model - are being applied to the new program at Talmadalayil, (the same state of Madras); a 600 million dollar project, of which 300 million is for 100 000 households worth of sites and services in ten cities, about 30 sites. Others will follow. For Velacheri, Madras, Rotner developed a version of the Bertaud model to handle initial pricing. A sample of that spreadsheet version can be seen in Fig. 9:

VELACHERI Initial PRICING

	A	B	C	D	E	F	G
67	Month.income hshd	400.00	600.00	850.00	1250.00	2000.00	3000.00
68	Plot size in m2	32.00	40.00	60.00	90.00	180.00	280.00
69	Plot type percent.	18.58	36.79	18.77	16.05	7.90	1.91
70	*NUMB. PLOTS/TYPE	**331**	**655**	**334**	**286**	**141**	**34**
71	Dev.land Rs/net m2	35.00	40.00	105.00	400.00	575.00	675.00
72	Superst.cost/plot	4442.30	7859.45	0.00	0.00	0.00	0.00
73	Other cost per plot	0.00	0.00	0.00	0.00	0.00	0.00
74							
75	*TOT.CAPITAL/HSHD	**5562.30**	**9459.45**	**6300.00**	**36000.00**	**103500.00**	**189000.00**
76							
77	Down payment %	0.00	0.00	0.00	25.00	40.00	60.00
78	" " lump sum	400.00	600.00	850.00	0.00	0.00	0.00
79	Interest rate/year	12.00	12.00	12.00	12.00	12.00	12.00
80	Loan term (year	20.00	20.00	20.00	15.00	10.00	5.00
81							
82	*MONTH.MORTG.PYM	**57**	**98**	**60**	**324**	**891**	**1682**
83	Water&elect.charg						
84	Other month.charg						
85	*TOT.MONTH.PYMT	56.84	97.55	60.01	324.05	890.95	1681.68
86	*** %OF MONTH.INCO**	**14.21**	**16.26**	**7.06**	**25.92**	**44.55**	**56.06**
87							
88	Home Expansion Loans	2000.00	3000.00	10000			
89	Monthly Payment	22	33	110			
90	% of Monthly Income	5.51	5.51	12.95			
91	**Total % of Monthly**	**19.72**	**21.76**	**20.01**			
92							
93	*DEVELOPED LAND COST RECOVERABLE PER NET m2					393.57	
94	*DEVEL.LAND COST/NET m2 TO RECOV. TO BREAK EVEN					295.04	
95	*SURPLUS OR DEFICIT IN THOUSAND AND PERCENT					11568.42	33.40 %

Fig. 9 Part of Bertaud model spreadsheet version for initial pricing

So the model, once again, survived the changing circumstances by adapting to them. But this time, what changed was not only the model use, but also the model itself; because the changes involved different roles by different actors - the public and private sector - , the model suffered a mutation and split into two different evolution lines. Fig. 10 illustrates this process:

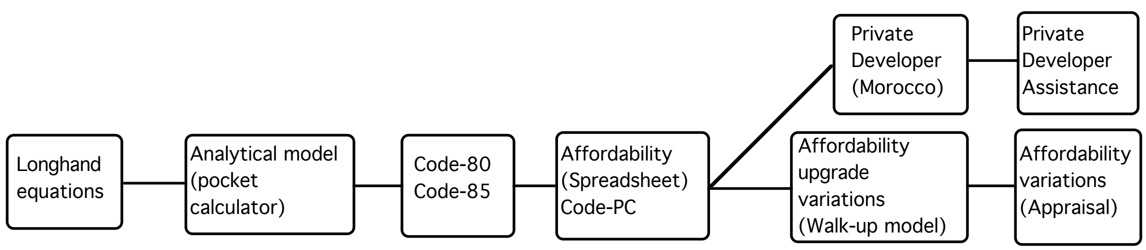

Fig. 10 Bertaud model splits into 2 lines of evolution

In the next two pages, Table 8 summarizes my findings on the history of the Bertaud model versions. The rapid evolution of information technology, more than anything else, promoted the first sequence of model versions. The advent of the spreadsheet software marks the beginning of a new sequence of versions, now more motivated by different needs in constant evolution than by new technology.

Next chapter provides a brief comparative analysis of the evolution of the housing policies, the model, and the information technology, before looking with more detail into the impact of technology on this process.

Year	Version Name(s)	Description	Hardware / Software	Projects traced	Notes
1970	Bertaud	Longhand equations, loose model yet.	Slide ruler Paper graphs	Haiti; [PADC 81] El Salvador; [Lina 92]	Model not formally used, but ideas sketched. [Bert 92a]
1977	Bertaud Prog.Calc. (Programmable Calculator Bertaud model) Padco / Bertaud Analytical Model	For Pocket calculators, programmable, with magnetic storage cards; 5 modules, or sub-programs which evolved from 1977 (31 equations), until 1981 (39 equations)	TI-59 HP-41 then, HP 67,97	Thailand; [Temp 80] Cameroon; Togo; [Erba 92] Indonesia; Dominican Republic; Nicaragua; Zimbabwe; Mauritius; Philippines; [PADC 81]	Supported by PADCO, for CITRUD and WB (report presented 1978); The Thai NHA funded another version of one of the sub-programs (II) Plotted curves were frequently used, instead of on-site use of the calculator
1982	Code-80 sub-model; or Detailed Land Use and Infrastructure Costing and Design Sub-model	Graphic module; Helps to design site plan. Works in conjunction with previous version, now called "Affordability Sub-model"	HP-80;	India, HDFC program review Jamaica [PADC 83] Guatemala, Quetzaltenango [Aust 86]	WB funded research on it (James Wright; South Asia Urban and Water Supply Division)
1983	Modelo Juliana	Version of the Prog.Calc. Bertaud model	HP,TI	Colombia, Ciudad Bolivar; [Ferd 83] Panama [Tacc 86]	"Pirate" version adapted by Londono Associates, Colombia
1983	Code-85	Graphic module; Upgrade of Code-80, for the HP-85 series	HP-85/ Basic,HP graphics (gpl); HP 86,87	India, Uttar Pradesh [Bert 84] India, Gujarat [Wrig 84]	Developed with a grant from the WB, while Bertaud was in India [Bert 92a]
1983	Affordability and Differential Pricing sub-model	Spreadsheet;	AppleII/Visicalc; HP110 (portable); Sharp 1250A /Basic; IBM PC / Lotus 123, Symphony	India, Bombay; [Rotn 85] India, Gujarat [Wrig 84] Jordan [Erba 92]	India: WB; Jordan: PADCO, in 1986. Later the Housing Bank in Jordan used model for appraisal of WB projects.

Table 8 - Summary of the major Bertaud model versions history (part I)

Year	Version Name(s)	Description	Hardware / Software	Projects traced	Notes
1985	Bertaud for Private Developers	Spreadsheet, extension & adaptation of the Affordability version	HP 85-87 / Visicalc	Morocco; [Aust 86] Jordan [Erba 92]	Morocco: Credit Immobilier et Hotelier, Special version adapted for evaluation; Jordan: USAID and Jordan Housing Bank, Private developer competition
1985	Code-PC	Graphic Sub-model translated from Basic version (Code-85); Used always with the independent Affordability Sub-model (Spreadsheet)	IBM-PC / Fortran	Tunisie [Erba 85] Somalia, Mogadishu [Olse 85] USA [Lina 92] Panama [Daug 92]	Version funded by IDB; EDI (WB) later supported upgrading version for IBM-PC. Tunisie: Credit Immobilier et Hotelier; USA: PADCO Project evaluation
1985	Walk-up model	Spreadsheet, extension & adaptation of the Affordability version	IBM PC / Lotus 123	China, Xangai; Lebanon, Beirut [Bert 92]	Beirut: Pre-feasibility only
1988	Affordability Sub-model	Spreadsheet, upgrade from Visicalc (and old Lotus) version. Used independently and sometimes with Code-PC sub-model.	Macintosh / Excel IBM PC/ Lotus 1-2-3 Excel allows iterations.	Malaysia; Indonesia, Jakarta; [Lina 88,89] India, Tamil Nadu; [Rotn 88,89] India, Madras II; [Rotn 92] Cairo,Egypt [Erba 92]	India: Appraisal, by WB; Indonesia: Perum Perumnas. Training and Site Selection
1992	Private Developer Assistance	Extension of Bertaud model for private developers	Macintosh / Excel	Training [Erba 92]	Programmed by Jerry Erbach, PADCO; Being fine-tuned.

Table 8 (cont.) - Summary of the major Bertaud model versions history (part II)

Milestones in the history of model use, low-income housing policies, and information technology

We came a long way, between Forrester's criticism in 1969 to the city fathers for building low-income housing when they should be tearing it down, and Lisa Peattie's cry that "we need more and better slums" [Peat 92].

In this section, the emphasis has been on the relationship between the evolution of the model, its use, and the evolution of the housing policies. That the model was influenced by the shifts in housing policies was to be expected; either that, or the model would have been left behind, as an obsolete curiosity. That the model helped to shape some of these shifts is more reveling, particularly in the face of the trend of skepticism about the role of models in policy making. However, the evolution of the information technology clearly molded the shape that this interaction assumed. This contradicts the (too many) urban planners that are ready to dismiss the influence of information technology as irrelevant in the greater scheme of things.

Perhaps in reaction to the earlier arrogance of the computer prophets and technocrats, IT is seen by many planners as a simple resource, not as a policy factor. I see at least two problems with this underestimation of the impact of information technology. On one hand, planners are not taking full advantage of the potential offered by current IT, either as a resource or as an enabling factor for new policies and institutional processes; on the other hand, planners (including urban policy makers) are playing a very small role among those who influence the directions taken by IT research and development, further increasing the gap between planners and other better served IT users -- like business and the military.

It is therefore useful to look at the all three life lines together. Table 9 (next page) gives a view of the milestones in low-income housing, information technology and the Bertaud model. The next and last section further discusses the diagram of mutual influences that can be abstracted from this table, focusing on the relationship between the model and technology.

Time Lines	1950 - 1960	1960 - 1970	1970 - 1975	1976 - 1980	1981 - 1985	1986 - 1992
Low income housing	WB started business as reconstruction bank, conservative banker (1947); Subsidized public housing policy;	WB as development lender (1960); Public subsidized housing and slum bulldozing predominant policy; Mangin exposes stereotypes on squatter settlements (1967);	WB targeting the poor (1970); John Turner writes "Freedom to Build" (1972); Sites and services, slum upgrading policies emerge; WB defends self-help housing (1975);	Limited success of sites and services; Emphasis on lowering standards and improving design efficiency in low-income projects;	WB as policy reformer (1980). Program loans instead of project loans; Emphasis on reforming Institutions and Agencies, as well as regulations;	Government as enabler, private sector as provider; City wide intervention, instead of targeting low-income areas; Emphasis on reforming legislation and financing mechanisms
Bertaud model	-	-	Freehand equations, graph curves [slide rule] (1970); Project Uses: Design and implementation	1st version, 5 sub programs [Programmable calculator] (1976); Project Uses: feasibility; design and implementation; evaluation of impact of standards;	Two sub-models: Affordability [spreadsheet] and Land Use and Infrastructure Costing and Design [graphics] (1982); Project Uses: site selection; design, implementation; evaluation of impact of regulations;	Private Developer Assistance model [modular spreadsheet] (1992); Project Uses: implementation; appraisal; evaluation of regulation reform proposals; profit / risk analysis;

Information Technology	Slide rule; First commercial computer UNIVAC 1 (1951);	Centralized non-portable computer mainframes - IBM 360 (1964) Non-Programmable Desktop Calculators	Programmable pocket calculators (TI, HP); Microcomputers with CP/M operating system (1973)	Desktop computers Apple II (1977); Spreadsheet software - Visicalc (1979)	IBM-PC (1981) ; IBM-PC /128K RAM (1983); Macintosh (1984);	Artificial Intelligence software for planning emerges - Intelligent urban I.S., Martinique (1986);

Table 9 - Milestones in Low-income housing, Information Technology and the Bertaud model

"Organizational and political factors can determine more than technical factors whether a model is used well, badly, or at all. "

Martin Greenberger [Gree 76]

"Without the technology, this analysis is just not possible."

Alain Bertaud [Bert 92a]

Section 3: The Technological Imprints

The impact of information technology and the model paradigms; Possible new directions for the Bertaud model.

The impact of information technology and the model paradigms

The first two sections delineated the essential of the relationship between the evolution of the model, the housing policy, and the information technology. This chapter looks into this relationship focusing on the IT side of the two-way mirror. Fig.11 diagram represents the mutual influence relations at the main steps of evolution, abstracted from tables 8 and 9:

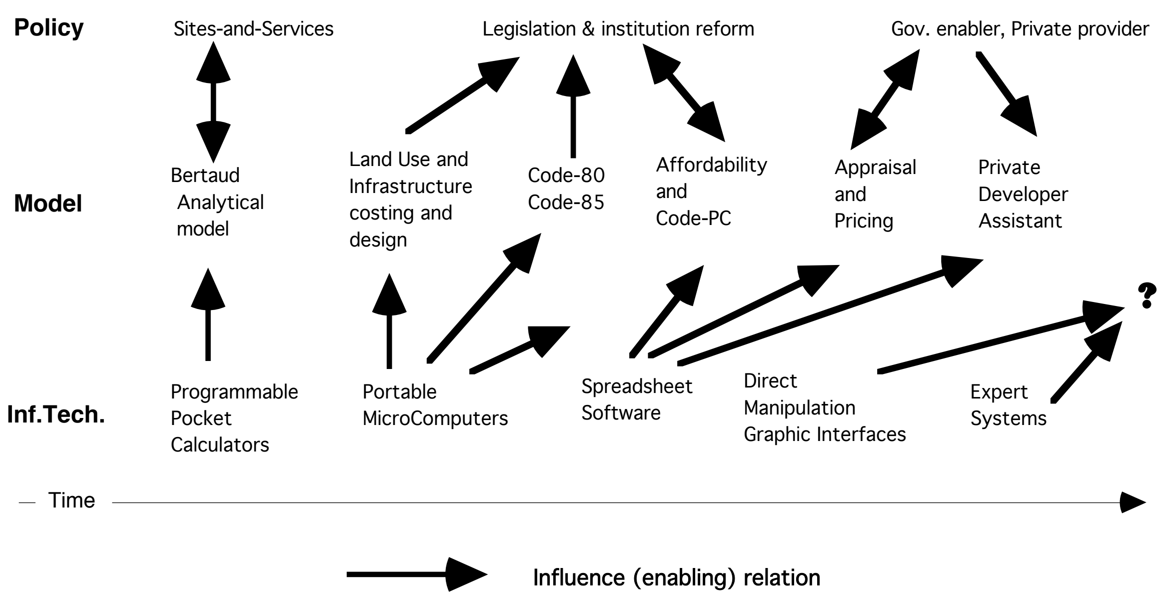

Fig. 11 Diagram of interaction between housing policies, information technology and the Bertaud model

This diagram calls the attention to several facets of this relationship, among which the different enabling effects of some ITs, and the unilateral nature of the relationship IT -> model.

One of such facets is the impact of specific IT on housing policies. In at least two instances it makes sense to apply the transitive property to the "enabling" relation:

• Programmable pocket calculators enabled (through the model) a better alternative to the traditional sequential planning process for low income housing, sites-and-services projects;

* Spreadsheet software enabled (through the model) the shift from project loans to program loans, allowing the major lender institutions to distance themselves from the details of housing projects (part of the "from provider to enabler" policy trend).

Other facet emphasized by the diagram is that two IT advances brought a qualitative jump: either in accelerating the model evolution, expanding its use, or in facilitating the influence of housing policies on the model, therefore its adaptability. In the first case, *desktop portable microcomputers* were the most significant IT development, among many other technological advances; in the second case, note that after the development of *spreadsheet software*, the number of arrows pointing from the 'policy sequence' towards the 'model sequence' increase substantially. Finally, the diagram highlights the fact that, while the model and its users had some influence on the evolution of low income housing policy, they had no part in guiding the evolution of the information technology (uni-directional arrows in the bottom half of the diagram).

Three main issues emerge from this global picture. The first is the issue of *portability*, as a focal point of the impact of IT in model use; the second is the issue of the difficulty of *interfacing planning and computer knowledge* - reflecting the little impact of planners in promoting or guiding IT developments; and the third is the issue of the *formulation of the model*, as a focal point of IT impact on model conceptualization (impact of software adaptability).

- <u>The portability issue.</u>

Portable computational power was undoubtedly the enabling technology for the development and use of the Bertaud model. It was already mentioned that while the mainframe computers of the 70' offered more than enough processing capacity, they were not easily accessed by planners in mission in developing countries. But it is not only the physical portability of a pocket programmable calculator that is a factor - and maybe not the most important one. Twenty years ago, most computing was done through a batch cycle: 'client' (a planner, for instance) -> system analyst -> programmer -> 'punch card' clerk -> system operator -> back to the 'client'. I had occasion to experiment myself with this environment. There was little or none Interactivity in the process (the users might not even see the computer, let alone interact with it); and this remoteness of the computer limited the access to it, the kind of useful applications and, in many cases, even the motivation to use it. Greenberger refers to this process:

> "The results from a computer run submitted to the computation center in the morning might be returned by the end of the day, on a 'good' day, or, more normally, sometime the following day. At a few heavily loaded centers, turn-around times ran to a week or longer. Estimating coefficients, experimenting with alternate equations, and statistically analyzing data were cumbersome activities at best. Many modelers preferred using the desk calculator in their offices for developing and testing their models to undertaking a disruptive series of trips to the computer center [Gree 76]."

It is therefore understandable that models like the Bertaud became only available - and put to use - when technology provided direct access and total control over the machine to the former 'clients' of the computer centers.

Another relevant angle of portability is the ability to transport the model program from one machine to another. This became an important factor in the evolution of the Bertaud model.

After the first model version, technology was progressing rapidly. The first really portable microcomputer was produced by Hewlett Packard, and was suitcase-sized, with a termo printer integrated, and a tape drive - no disk. It had 32 K RAM and at the time it looked enormous, as people were used to calculators. With a grant from the research committee of the WB, Alain Bertaud started programming on this microcomputer using Basic and HP graphics, while working in India on an operation. It was named code 85 (because of the HP 85). It worked well, and Bertaud used it himself on the mission; but it took him a year to develop it, debug, test it in the field, and add more parameters which he felt were important. In one year, the technology had already changed: IBM had come up with a PC, DOS became the standard, and Bertaud was 'stuck' with his HP and HP Basic (which at the time was built into the machine and ROM based). For anyone else to use it, they had to have a HP 85, period; there was no portability.

So the next step was to transport the model to a PC. Bertaud had spent much time developing on this machine but, although it worked well, he couldn't really recommend users to buy a HP computer that was obsolete, just to use his model. Being no professional computer programmer, he didn't have enough time to spend another year, or even half a year, to transport the program to a PC. One consequence of this was that the one part more frequently used was the affordability sub model, without the graphic sub model -- Code 85, because it was easy to transport this component to Visicalc (an early spreadsheet) very quickly, with the added advantage that Visicalc worked on both the PC and Apple II.

However, the graphic component had a strong appeal to it, being an impressive visualization of the model on the works, and tackling one area of project where the use of computer aid seemed promising and rewarding. It was during the efforts to upgrade this component that became clear the gap between the computer and planning worlds.

- <u>The issue of the difficulties of interfacing planning and computer knowledge.</u>

The IDB, Inter-American Bank for Development, was doing more and more sites and services. They were very interested in the Code 85, but they had the same dilemma - there was no point in dealing with the by then obsolete HP machine. So they were ready to finance someone that could program it. They decided themselves to do it in FORTRAN, and recruited a programmer that was comfortable in FORTRAN (at the time, there were several versions of Basic, and Pascal was emerging).

The programmer worked closely with Alain Bertaud, and developed a version of Code 85 in FORTRAN, called CODE PC, since it was targeted for the PC. He was a professional programmer and didn't know about the field work domain and the use of the model. They had a lot of problems. From Bertaud's point of view, the programmer could not understand the operational aspect of transparency. First, the programmer wanted to have computer prompts for variable input, one at a time -- by then the typical data entry format in administrative applications. Bertaud wanted to have an interface as in Visicalc, where the user has a table with all the parameters, and he or she can go in any chosen sequence with the whole set of alternatives visible right away, rather then have a question on screen saying "do you want several plot sizes : Yes/No". Bertaud wanted to have a table where if he wanted to have only one plot size, he could put 0s into all other plot size slots, etc.

They also had a problem with scales: the programmer always wanted to have graphics which fit on a page, because he was used to business graphics; Bertaud wanted to have graphics to print at the scale he wanted. If he printed a map it had to be at a scale that he could recognize; even if it had to be printed on several pages that he glued together, but knowing that they were at, say, 1:1000 scale. For an architect or a planner this means something, but for a programmer trained in a technology largely driven by business and administration applications, it doesn't make sense if it doesn't fit the page.

These problems are a very good illustration of the consequences at large of relying exclusively on "free-market" guidance for computer technology developments and respective training skills. Tools and concepts targeting business, administration, military, are not necessarily applicable to other domains, nor will they necessarily give way to spin-offs such as analytical tools for planners. The story of the Bertaud model is a strong argument in favor of the need for agencies and institutions with planning responsibilities - including Planning Schools in Universities - to take the lead in supporting domain-oriented computer R&D, and particularly in encouraging the acquisition of in-depth computer expertise by planners that show inclination and talent for such.

The old way of doing things shows in the least expected places. For instance, World Bank senior staff in charge of large housing programs and with considerable computer expertise, like Evan Rotner, have old and obsolete Macintosh 'Plus' on their desks, if any at all, instead of being supplied the latest vintage in desktop and portable technology...

<u>- The issue of the formulation of the model.</u>

A less obvious but not less interesting impact of the evolution of information technology on the model, was the way it affected the conceptualization of the model.

The first version for the calculator has the distinct marks of constraints imposed not by the theory, nor by the convenience of use, but by the technology: the propagation of effect of change in value in one parameter is filtered through a few variables, with a "funnel" effect, losing in the process the ability to reflect other interdependencies. There is a problem in funneling links through one variable between pairs of modules. Modularity is good, but this funneling creates a) a bottleneck of only one input; b) rigidity in transmitting multiple influences and a possible "hill-climbing" effect; c) no easy two-way propagation, since it is hard, for instance, to transmit a change in capital affordable per household to the several variables monthly payment, year's interest rate, recovery period(years), and down payment (%).

So in fact, this is an example of how IT constrained the conceptualization of the model. While Bertaud was putting together the model, after getting acquainted with the programmable calculators, he could not ignore that there was no other way to program this into the calculators, because a) the limited capacity of the magnetic cards imposed modularity, by limiting the maximum size of each program; b) limited memory (registers) imposed a constraint of only a few parameters as a link between the modules.

Modularity, by itself, does not simplify use of the model; it can become, on the contrary, an extra burden. Take this example: "Program I calculates the amount of capital affordable per household if level payment loans are used. If graduated payment mortgages are used, the capital affordable per household can be calculated with program IV and substituted in program I". This means that the user has to 1) remember when program I is not valid; 2) remember which program to apply instead; 3) perform an extra separated calculus; 4) make an extra insertion into the main program. It is good to have the ability to "plug" and "unplug" pieces of a module according to each case; but it is much better if the "plugging" and "unplugging" is made automatically, with the system able to discern when to switch modules and which modules to use, or at least able to guide the user in the process.

Spreadsheet software liberated programmers from these constraints, and the feeling was so strong that programmers talked of this software as bringing "total transparency". But the fact is that spreadsheet programming forces problems - and models - to be formulated in terms of a "cell algebra", relating variables and formulas with grid cells. One consequence is that intermediary "dummy" variables are created and included in the model for no other purpose than the one of facilitating "cell algebra" calculations in the spreadsheet. Other consequence - aggravated by the multiplication of "dummy" variables - is the opposite of transparency: a user inspecting a spreadsheet to perceive the model behind it will find "transparent" things like: "=E23*F24" in one cell, and if he or she is brave enough to follow up, runs the risk of finding in cell E23 something like "=H65*(Y65-$R34....), etc. Recent versions give the option of naming cells, which is a big improvement in terms of clarity, but naming intermediate expressions is not straightforward and usually follows a personalized mnemonic strategy, unreadable by anyone else but the author. Nevertheless, for a frequent user, the spreadsheet allows with relative ease infinite variations and adaptations to particular cases, which is extremely important.

In general, we can say that model conceptualization has evolved from a sequential, step wise paradigm, towards a parallel, network wise (with feedback loops) paradigm. It is reasonable to expect that modern advances in software engineering, from object-oriented programming to artificial intelligence, may bring with them different and more powerful forms of knowledge representation and modeling. It is therefore not farfetched to assume that the inclusion of such curriculum in planning schools will be an important factor in producing a new, powerful generation of models in planning.

Possible new directions for the Bertaud model

There are good conditions for further evolution of the Bertaud model. On one side, the increasing participation of private developers in low-income housing projects will stimulate new advances and refinements on the model, in aspects like risk analysis, detailed costing in housing units finishing, and analysis of the effect of regulations. On the other side, the recent advances in computer technology -- hardware and software -- open the possibility of great improvements in the model interface (e.g. data visualization), and scope of analysis (e.g. dealing with qualitative or uncertain data).

In this chapter I will consider the following issues: the use of an inference net of qualitative relationships; using GIS as a new base for implementation; and alternative bases for implementation.

- <u>Inference net of qualitative relationships.</u>

Playing around with standards may have less obvious side-effects, not apparent in the model, but nevertheless with no less serious consequences.

Hooking the mathematical relationships in the model to an inference net will allow, at the least, the ability to identify and alert the user for non obvious primary and secondary consequences of certain options (particularly outside his or her area of expertise) and, possibly, to capture threshold effects that otherwise will remain hidden or obscured by the overall constraint-propagation calculations. Examples of this include: below a certain standard of sewage, there is a potential damage to water springs and public health; below a certain percentage of open space, there is a sharp increase in the cumulative effect on health hazards and social problems; above a certain level of extracting water, there is a steep increase in the risk of damaging the underground water table, with a chain of other secondary consequences; etc.

Another aspect of qualitative relationships is to consider (gauge) the effects of bringing development to an area, upgrading infrastructure, and changing land uses. The most straightforward example is a low-income family residence area becoming a medium-high income residence area, as a result of a dynamic of social pressure, developer efforts, and also of (understandable) opportunistic behavior (low income beneficiaries selling and settling in another non-developed area or slum). But other effects surface, such as the example of the Tunisian village Nador, where the arrival of electricity changed the traditional occupation of many inhabitants from fishing and farming to industrial carpentry and welding; and a new water pipe extended the perimeter of cultivated land (but not the residential area), and rearranged the geographic pattern of land prices.

Since it is hard, if not impossible, to quantify these impacts, it will be interesting to study them and build this inference net with known cases where evidence of these cause-effect relationships were found (or suspected to exist). Then the system "model+knowledge base" can search for a best match with the current scenario, or infer a composite generalization, and advise the users accordingly.

- Using GIS as a new base for implementation.

The strong points of using GIS are related to its ability to display spatial relationships and their response to what-if scenarios. Examples of this include the ability to:

- Display land sites satisfying a land price constraint;
- Display projected plots according to tentative design, calculate areas and all area-dependent values (land price/plot, for instance);
- Display projected public spaces, calculate areas, and percentage of total site area;
- Display infrastructure network, calculate lengths, and all length-dependent values (pipe cost/plot, off-site pipe costs, for instance).

There are, however, important weak points or limitations in the ability of a "traditional" GIS to handle the model implementation. It is not easy to represent and "play" with relationships between areas, lines (networks) and points, when in fact this is the essence of a "constraint-propagation" model such as Bertaud's. Examples of this are:

- Change size of plots when given a different value for the diameter of water pipeline, keeping price/plot constant;
- Change size of plots when given a different layout of off-site infrastructure network, keeping price/plot constant (or overall costs constant);
- Change size of plots and reorganize layout when given a different value for overall percentage of open spaces.

One good reason why these operations are hard to implement, in any kind of environment, has to do with the fact that in most cases, there is no unique solution for each change in the scenario (there are frequently many possible layouts for the plots satisfying the new conditions). This complicates the interaction, since we have either to further input other constraints, or to accept a 'hard-coded' selection.

But another reason for the difficulty here is that GIS is not traditionally made to produce layouts; the assumption in GIS software is that you input a given map, or collection of boundaries (polygons), lines and points, then associate certain attributes with each one of these elements, and then you are ready to perform operations with this "base map". In short, GIS alone is not a simulation environment.

- <u>Alternative bases for implementation.</u>

The recent development of object-oriented programming languages opens new possibilities to model implementation. I propose to introduce the notion of "Intelligent Element", as the base for implementing an object-oriented version of the Bertaud model. The notion of "intelligent element" is the following: each element (a plot, a house, a pipe, a street) knows with whom it is related, and how. If a value is changed, messages are dispatched to the necessary elements with that information. This way, multiple links are possible and transparent. The description of these "intelligent elements" can be easily achieved using knowledge representation paradigms such as frames, active slots and daemons, or the 'society of agents" construct proposed by Marvin Minsky [Marv 86].

A key issue in upgrading the implementation of the model, is the visualization of output. It is not simply a matter of displaying layouts of plots; it is also a matter of visualizing the propagation of the effects of changing a value in a parameter. This is not trivial, since some of these effects are quantitative non-spatial, others spatial, and others qualitative (such as thresholds feasible/non-feasible in regard to physical, economic, political and other constraints). Furthermore, the display of large amounts of numbers when dealing with quantitative data can be overwhelming, and make the interpretation difficult. This is a good example where intelligent graphic interfacing can help [Ferr 89]. A couple of examples:

- Intelligent dialog objects can "pop-up" when (and only when) some significant threshold is crossed: they can show a simple color code (e.g. red/yellow/green semaphores, or flags, or thermometers), or a value; clicking on the dialog-object will allow zooming into more detail data, if so desired. This allows for quick-glance global analysis;

- While using the model, a window can display a graph representation of the model, where the parts of the model that are made active (for instance, calculating the effects of changing a parameter), will be highlighted. The same representation is possible for parts of the expanded model in the form of an expert system (inference net). This allows an explicit visualization of the "constraint-propagation" effect, providing a better understanding of the model and of the kind of implications associated with each parameter change. It also provides an excellent tool for qualitative sensitivity analysis; some changes will only highlight small portions of the model, displaying a "localized behavior", while others will propagate everywhere, displaying a global effect.

During this research, I experimented representing the Bertaud model with different programming techniques and developed two simple prototypes: a "Spreadsheet Glossary" [Fig. 13, 14] (to help translating at run-time the "cell algebra" into formulas with full-named variables), and a "Simulation Support System" [Fig. 12] to provide a kind of direct-manipulation user interface to the Bertaud model (for instance, the user changes on screen the size of plots, and can see the immediate propagated effect to other variables, including color signaling (green / red for acceptable/non-acceptable parameters), not unlike the proposed "intelligent elements". To illustrate some of the concepts discussed above, I include Fig. 12, 13 and 14, showing samples of screen activity of these prototypes:

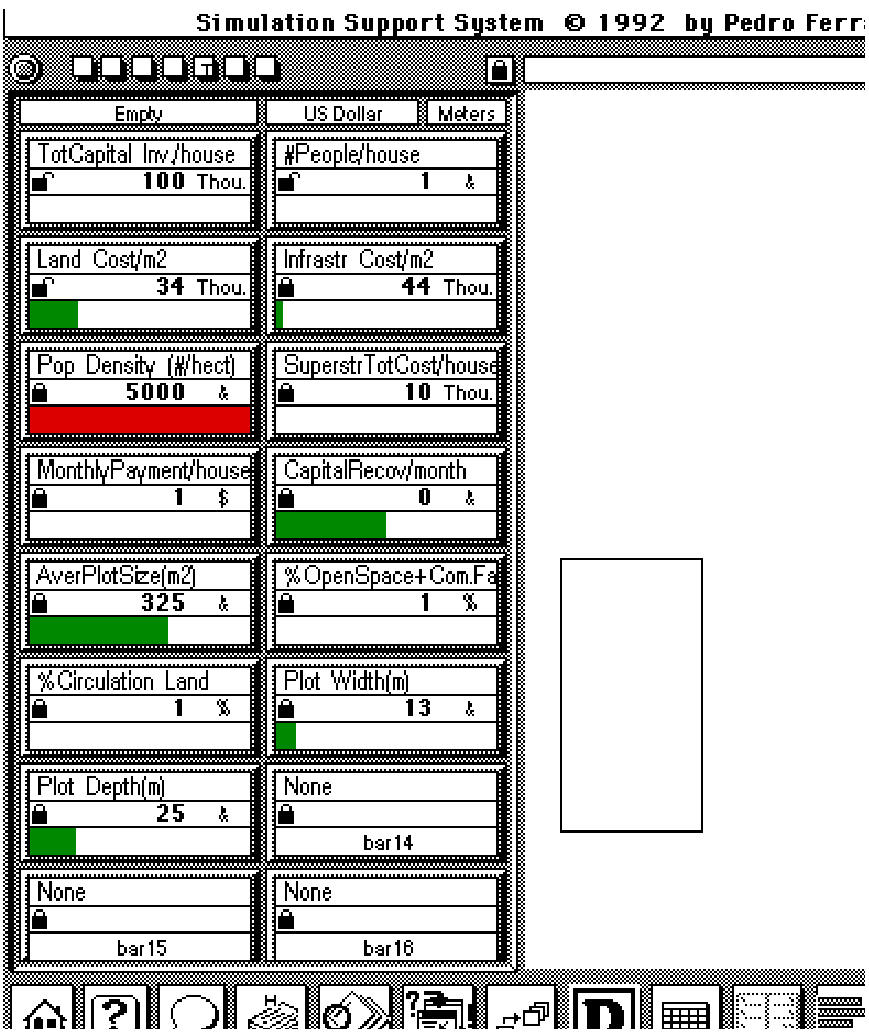

Fig. 12 Example of visualization of the Bertaud model using intelligent elements (bars display green or red color)

The detailed description and discussion of these prototyping experiments are out of the scope of this article; nevertheless, its results reinforced my conviction that there is great potential in exploring these paths, upgrading the Bertaud model computer representation and particularly its user interface. Given the rich experience accumulated with the multiple uses of the model and the promises of the recent IT developments, the Bertaud model stands a good chance of prolonging its useful life for many years, and reward the efforts made towards its upgrading.

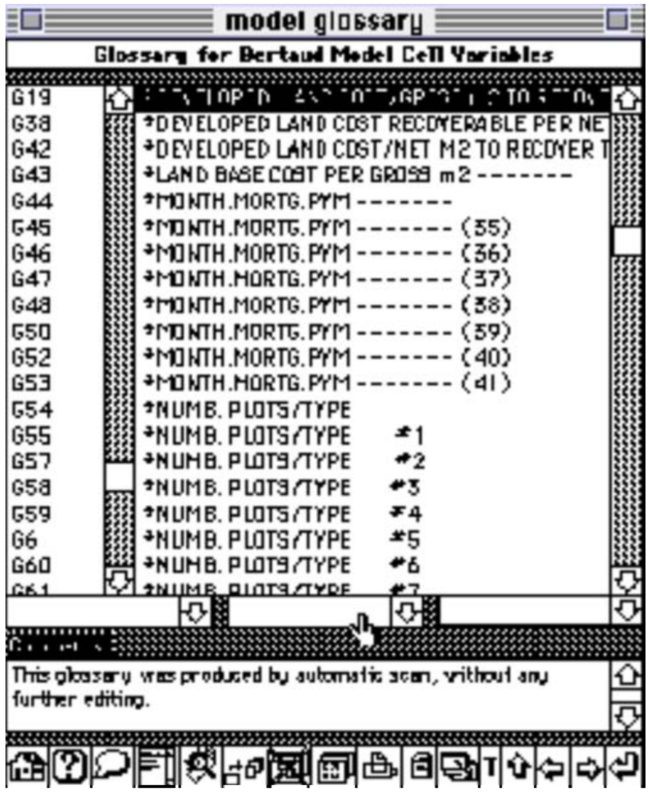

Fig. 13 Index of glossary for spreadsheet with Bertaud model

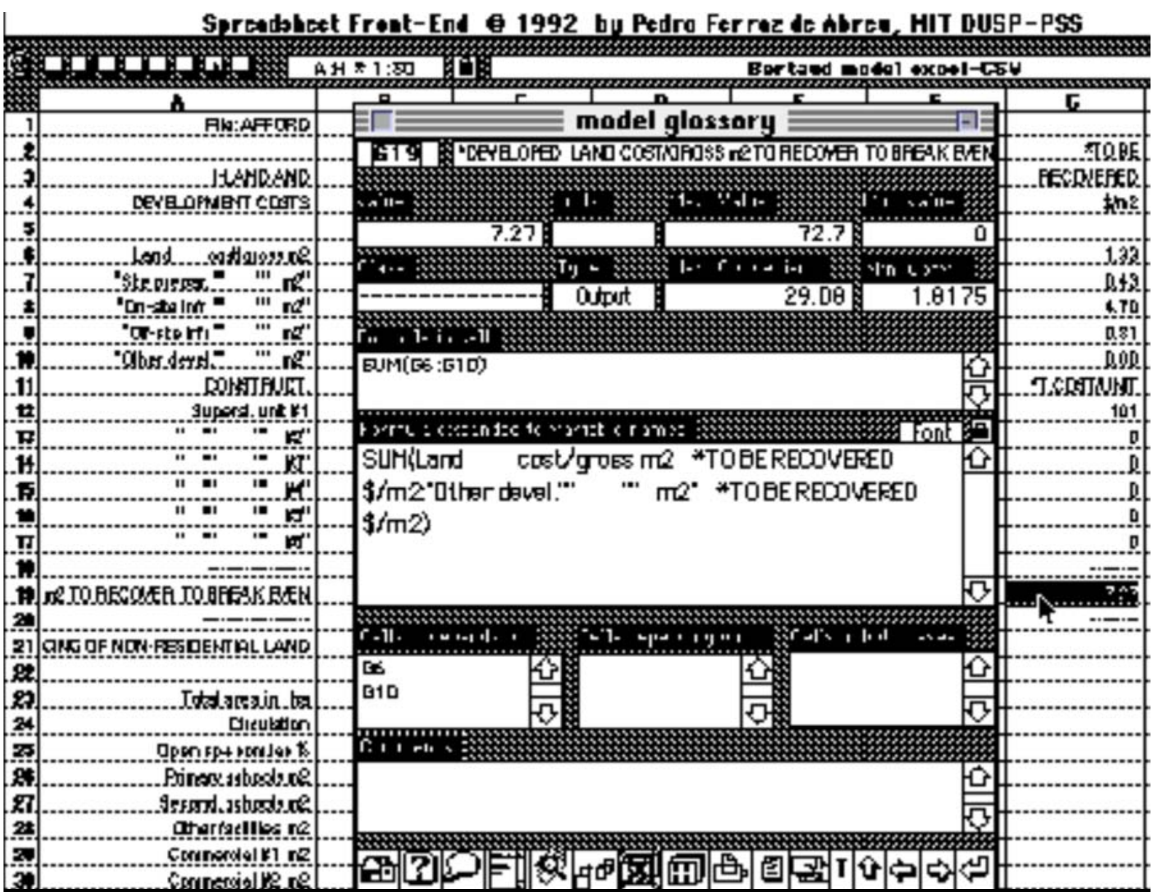

Fig. 14 Glossary being used to translate cell G 19

"Politics are for the moment. An equation is for eternity"

Albert Einstein

Conclusion

There is good evidence that the Bertaud model mirrors both the technological and housing policy developments, as a tool of transformation as well as the object of transformation.

The model had a significant impact on the site planning process, in low-income housing projects, by substituting in many cases the traditional sequential planning-engineering-finance process by multi-professional dialog. But the model failed to affect in any significant way community participation: more because of institutional reasons, less because of technological limitations in the model expression.

The model also played a visible role in the shaping of housing policies: by helping to show the impact of inappropriate high standards, and the consequences of obsolete regulations, many of which adapted from colonial times. But in the process, the model exhausted in a certain way its usefulness in this domain, since one of the consequences of this policy re-shaping was the loss of interest in sites-and-services projects by the major development agencies, who concentrate now in city-wide efforts, not specifically targeted to the poor, and intervene now more in the legislative and financial domain.

However, the model found a new institutional role, as an appraisal tool that made viable the WB policy shift from "many small project loans" to "few large program loans"; and is resurfacing as a valuable tool for a new type of user: the private developer. These private actors can rightly call the model just as well "the affordability model" (when using it to check conformity with standards and regulations), as "the profitability model" (when it uses it to determine the potential margin of profit and corresponding risk).

As for information technology , the key development was not computational power, but portability: the ability to take the computer on-site (on the hardware side), the ability to use and customize the same spreadsheet programs across platforms (on the software side). It is reasonable to assume that the referred improvements in the planning process would not have been possible without such technological developments.

The evolution of information technology clearly impacted on the conceptualization of the model. Both the calculator and spreadsheet versions have the distinct marks of constraints imposed not by the theory, nor by the convenience of use, but by the technology. The "funneling" of the propagation of the effect of changing parameter values, filtered through a few variables, is one illustration of the earlier constraints; intermediary "dummy" variables included in the model for no other purpose than the one of facilitating "cell algebra" calculations is another illustration, for the spreadsheet version.

The spreadsheet was a major revolution advancing model programming, but its strengths had unforeseen effects, like the de-characterization of the core model, with multiple variations facilitated by the easy customization (Erbach talks of the loss of the "*pristine quality, say beauty, of the initial curves* [Erba 92]"; and as the complexity of the model customization evolves, cell algebra tends to make spreadsheets less and less transparent. Although more modern software -- object-oriented, expert system hooks -- is well established in other domains, it is once more lagging behind within the planning world, where it continues to exist a scantiness of computer-based analytical tools.

The secret of longevity of the Bertaud model contains one powerful ingredient -- the technologies supporting adaptability. This ingredient is not an absolute priority everywhere, nor was it the main thrust of IT research and development. The story of implementation and upgrading of the Bertaud model, with its obstacles and successes, shows that IT advances in serving business and administrative applications do not satisfy automatically the computer needs of the planning community; it suggests a strategy of planning institutions and agencies investing and supporting R&D in domain-specific computer technology, building strong IT curriculum in planning schools and forming its own 'corps' of dual computer-planning experts, rather than relying in the blind guidance of the "free-market" dynamics.

Finally, an interesting effect of the use of the Bertaud model was a less confrontational approach to face different views. As Alain Bertaud said to me, "*the advantage of putting it in a model form is that you can be very neutral; you can say 'this is my model, the result [that] has come out is that if you don't have 5 meters, you have 6, you have to subsidize the difference; so this is so much it is going to cost in capital cost'. You put a price tag. [You ask] 'do you really think it's worth it for 1 meter difference in a frontage... is it worth this amount of money for the taxpayer, or not?' Then it become much more acceptable. If you say right away -- 'your legislation is crazy, 6 meters is wrong, 5 is good', you can never win, because, well, 6 is better than 5 after all, if there is no price tag on it. If you don't have a model, you have to say this is crazy, don't do that; if you have a* *model you say yes, your transport costs, your subsidy, will have to increase by that much per year...this way, you don't antagonize anybody, you just analyze.* "

Although the less confrontational effect is not particular to the Bertaud model, since the same can be said about any trade-off model in general, this facet clearly played a role in its ability to improve the planning process and influence policy changes for low-income housing, and best summarizes the planners' view of the model. "*A model facilitates reasoned debate, and this is a plus for models in policy"*, says Greenberger, but this contrasts with arguments often heard: *"Many would counter and maintain that the political process depends on the lubricants of ambiguity and imprecision in reconciling the positions of different interest groups. The dry definitveness intrinsic to a model grinds against the gear wheels of political machinery* [Green 76]."

This "dry definitveness" may have been true for the generation of "star" urban models in the 60's. That this view does not apply to current models like the Bertaud's, is highlighted by the evidence that, although not primarily made for policy analysis and recommendation, the Bertaud model has had in fact more durable impact in the housing policies than models like Forrester's "Urban Dynamics".

Despite the challenge of the unfulfilled promise - helping the dialog with the citizens and communities affected by housing policies and project decisions - a new generation of models, to whom the Bertaud model belongs, are bringing home solid evidence of the strengths of model-based planning and policy making: time savings (translating into less transaction costs), richer decision space (more alternatives considered), bridge between different professional value-systems, increased efficiency in implementation and appraisal. Without fanfare, but with a vitality that defies the sounds of the announced requiem.

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Glossary and abbreviations

CITRUD - Center for International Training and Research in Urban Development.
EDI - Economic Development Institute.
HP - Hewlett Packard.
IDB - Banco Interamericano de Desarrollo (Interamerican Development Bank).
Mainframe - A large central computer connected to several terminals.
PADCO - Planning And Development Collaborative International.
Spreadsheet - A two-dimensional matrix program, designed for microcomputers, which can do calculations, manipulate data, and build models.
SPURS - Special Program of Urban Studies.
URISA - Urban and Regional Information Systems Association.
WB - The Bank - World Bank.
TI - Texas Instruments.

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