LeapTec

On good models, bad models, output, and history

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1. Introduction

Ordinarily we would not write this report. However, GAO has asked that we juxtapose model output and historical time series. Our desire to have a satisfied client outweighs our concern about the value of such a juxtaposition.

Our concerns are two fold: First and foremost, we do not want to give credence to the erroneous belief that good models match historical time series and bad models don't. Second, we do not want to over-emphasize the importance of modeling to the process which we have undertaken, nor to imply that modeling is an end-product.

In this report we indicate why a good match between simulated and historical time series is not always important or interesting and how it can be misleading. Note we are talking about comparing model output and historical time series. We do not address the separate issue of the use of data in creating computer model. In fact, we made heavy use of data in constructing our model and interpreting the output -- including first hand experience, interviews, written descriptions, and time series.

In the next section (Section 2), we briefly present the methodology we have used, placing modeling in the wider context of developing understanding of and improved performance from social systems. Then, in section 3 we explain why comparing model output to historical time series is not a useful test for certain classes of model use. Section 4 describes the difficulty in choosing a run setup for a comparison to history. Section 5 discusses the issue of absent structure. Finally in the sixth section we present the juxtaposition, and cannot resist making one last warning that the apparently good fit is not cause for celebration.

2. The model is part of a process

We have tried to construct logical arguments about endogenous processes that might cause future financial guarantee programs to go awry. A system dynamics process led to those arguments. Modeling is only part of that process. The process includes these steps

1. Describing the problem as a behavior pattern over time -- which leads to a more dynamic view of the problem, and a view that is amenable to the subsequent steps. (See Report 1.1.)

2. Creating theories of the problem in terms of loopsets -- each of which contains a complete chain of causality (i.e. the cause of everything in the loop is contained in the loop). Loops are the cornerstone of system dynamics; they are capable of creating behavior patterns all by themselves, nothing else in the world can do so. (See Report 1.1.)

3. Linking the loopsets together -- which gives a larger picture of the problem, preventing "myopia", and which helps one understand how the theories tie together structurally. (see Report 1.2)

4. Building computer model(s) -- which causes one to be more specific about the structure of the theory. (See Report 1.3, and the partial model documentation in Reports 2.1,2.2,2.3, and 2.4.)

5. Using the computer model to further explore the argument (See "On the Use of Models for Learning and Insight" in this Report 3).

6. Articulating the theory in terms that an audience can understand. (See Report 1.4a, the analytical Report s in Reports 2.1,2.2,2.3, and 2.4, and the lever report in this Report 3.)

Modeling is useful, even critical. But modeling is only part of the process and the other parts are critical, too. Furthermore, the model itself is an intermediate product in the larger process. The end-product of the process is a theory or logical argument about the real world.

3. Matching model output and historical time series is not always a useful test.

Many people mistakenly believe that a good model will match historical time series from the real world and that a bad model will not. In fact, comparing model output to history cannot in the general case distinguish good models from bad models.

The mistaken belief that models should match history is based on certain specific classes of models or uses of models where such a match <u>is</u> important. For example, the correspondence between model output and historical time series will obviously be important for models used to investigate the reasonableness of the historical time series. Further, a large class of models are those whose output is taken as a prediction of the future. Here, someone wants someone else to *believe* the output of the model. Comparing model output to historical time series in effect puts a character witness on the stand: The model has not lied in the past. It is important to realize, however, that the importance of a match to history in these cases is quite specific to the particular needs of these classes of modeling effort.

Our use of models falls outside these classes: We have not used models either for prediction or to support our arguments and have not asked anybody to believe our models. We are not even sure what it would mean to believe our models -- any more than we know what it would mean to believe our pencils or any other tool we used. Our use of models has had little to do with belief and a lot to do with argument creation. We used our models as aids in the design of our arguments. It is the argument that is important, not one of the tools that was useful in producing it.[1]

More specifically, we use our models as analogies. Analogies are common and powerful ways of obtaining insight, but it is the insight that one wants to test, not the analogy.

Consider an example: A reporter for, say, *Fortune Magazine* might be asked to write something insightful about entrepreneurs. The reporter might hit on the idea that the relationship between the businessman and his business is like a marriage. In this case the model is the marriage and the real world is the entrepreneurial endeavor. The reporter would first think about his model: Marriages have their ups and downs and require perseverance. The next step is to ask whether ups, downs, and perseverance also characterize the real world of entrepreneurship. The answer is probably yes. But, perhaps the reporter knew that already, and so far the model has not yielded very much.

Thinking further, the reporter might consider that marriages often produce children. This jogs his thinking: Perhaps the business itself is the "child" of the entrepreneur. In this case a host of possibilities arise: Perhaps entrepreneurs respond to threats to the business in a highly emotional way. This gets interesting: perhaps, the founder of a business will fail to act logically at key times when his business is threatened.

We can use the example to consider the relationship between models (here, the marriage) and arguments (here, entrepreneurs are emotionally tied to their business, and, as a consequence, they may fail to act logically at key times):

1. The model helped produce the argument or theory. But, the argument stands or falls on the basis of its own logic and whether it is consistent with information about entrepreneurs. The argument is disconnected from the model. In particular,

2. A fit between the model and the real world is not evidence in favor of the argument: The fact that parents love their children is not evidence that an entrepreneur will react emotionally to threats to his business. And,

3. A lack of fit does not invalidate the argument: Grandparents often care for children when parents go on vacation, but do not typically care for

[1] For an example of how we used models see "On the Use of Models for Learning and Insight" in this deliverable 3.0.

a business when entrepreneurs go on vacation. Here, the model does not fit the real world. But the lack of fit is irrelevant and does not invalidate the reporter's argument.

Our use of computer models can be seen as a process of constructing an analogy of the real world and then using that analogy to jog our thinking along. A fit between the analogy and the real world is not the issue. Analogies -- whether computer based or not -- are useful if they lead to better understanding and are not useful it they don't.

4. The problem with starting conditions and test disturbances.

All of our runs have involved disturbing the model from an equilibrium via one or another idealized test input . These test inputs are designed to excite the dynamics of the model in a way that is amenable to analysis. The test inputs do not correspond to any historical disturbance in the real-world system, which in any case did not begin in equilibrium.

We have produced hundreds of simulation runs. Each run produced different simulated time series for the variables presented here. Each run differs from the others in starting conditions and/or test inputs. Selecting output means choosing which test inputs to trigger, and where to start the equilibrium. (With no test input, the model simply sits in a stress-free equilibrium.) In the end we decided to set the model with all structures active.[2] We set

IncrDesPurch = 1
InputPressureToExpandFip = 0.1
tunRationing = 1
tunStretchLiq = 1
swForPurchTrend = 1
swForVariableLFS = 1.

The effect of this is to have a run which starts in an equilibrium where GBEs are very small players. Beginning at time 2, the FLIP is subjected to a continuing pressure to expand its boundaries. (See Report "Expanding the Boundaries of Federal Loan Insurance Programs" in Report 2.4.), the GBEs begin to compete with each other (See LeapTec Analytical Report "GBE Competition: Credit Standards and Purchasing Your Way Out of Problems"), and the fraction of loans sold to GBEs begin to expand in an S-shaped pattern. (See "Lending Your Way Out Of Problems", p.15-16, in Report 2.1.) These disturbances will also activate the price expectations structure (See LeapTec Analytical Report "Extrapolative Expectations in Financial Guarantee Programs", in Report 2.2) and the originators' lending-your-way-out-of-problems structure. (See LeapTec Analytical Report "Lending Your Way Out of Problems", Report 2.1.) Our data generally runs for about 30 years, so we ran the simulation for 30 years.

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[2]More precisely we activated those structures in the model which we think might actually operate in the real world. This set includes all the structures we modeled except that for primary lender competition, for which we could find no evidence. (see LeapTec Analytical Report "Primary Lender Competition", Report 2.1).

5. The Problem of Missing Structure

A question might arise whether one it would be useful to examine a run which started from conditions similar to those of a particular year and which used exogenous inputs that mirror real-world disturbances. The answer is that one would still not have useful test.

Our model -- constructed to explore financial arguments -- lacks structure that is also moving the data around. Consequently, the one path the model output should not follow precisely is the historical path.

We could still tune the model to match the data quite precisely. To do so we would need to choose parameters that would make the structure we *do* include mimic the behavior of structure that we *do not* include.[3] This would not tell us much about our model or the parameters. Tuning our model to the data would not make our model more useful, nor our arguments truer.

6. The Juxtaposition

We turn now to a juxtaposition of model output and data. We believe that the following shows all cases in which the definition of an endogenously calculated model variable closely matches the definition of a real world time series shown in our previous reports. We also indicate where the real world time series was used in our prior reports.

The model, with the setup described above, in general reproduces the pattern of the reference modes. The preceding sections explain why that match is not of much interest. The match is deceptively attractive: It appears to lend credence to our work, but in fact the match doesn't mean anything. Using the match as support for our arguments would mislead people about the nature of our arguments and about the way we used models.

House Price (See Figure 3, LeapTec Report 1.4a, Figure 3, LeapTec Analytical Report "Lending Your Way Our of Problems, Report 2.1, Figure 3, LeapTec Analytical Report "Extrapolative Expectation in Financial Guarantee Programs", Report 2.2; Figure 1 LeapTec Analytical Report "GBE Competition: Credit Standards and Purchasing Your Way Out of Problems"; Report 2.3; Figure 1, "Expanding the Boundaries of Federal Loan Insurance Programs", Report 2.4.). Figures 1 and 2 below show actual and simulated time series for similar variables. Figure 1 presents actual data for Real Average House Price and

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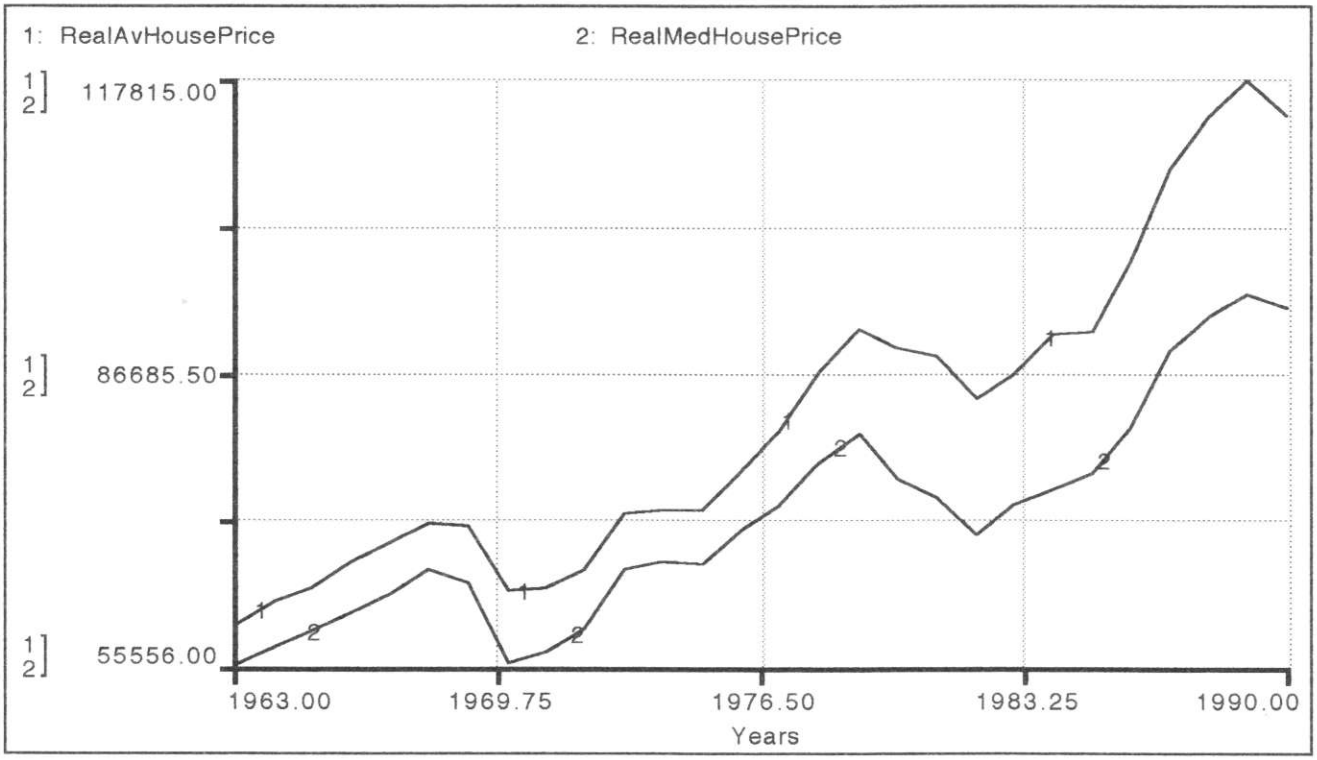
[3]For example, our model, which focuses on financial theories, lacks a construction sector. The cyclical pattern in some of the data might be caused in part by a construction cycle. With a shrewd choice of parameters, we could probably get similar cyclicality from potentially oscillatory financial loops. In this case the reward for achieving the fit would be distorted parameters governing the oscillatory loops. See appendix to LeapTec Analytical Report "Extrapolative Expectations in Financial Guarantee Programs" in LeapTec Report 2.2 for a discussion of oscillatory financial loops and the structure that may lie behind the construction cycle.

Real Median House Price; Figure 2 shows behavior of the model variable housePrice (because there is no inflation in the model, this variable corresponds to a real price). Both the model output and the data rise. The model output begins at a different value, but one must be careful about comparing price levels. The model does not show the same sort of oscillation as the data.

Figure 1: Real Housing Prices, 1963 - 1990[4]



Source: Nominal prices for new houses were compiled from U. S. Census Bureau, Construction Statistics Division data from *Current Construction Reports*, Series C-25, New Single Family Houses Sold, Unpublished History File, January 1991. Real prices for house values were calculated using the implicit GNP price deflator from Table B-3, *Economic Report of the President*, February 1991. Real House values were computed by dividing the nominal values by the implicit GNP price deflator, divided by 100. Data plot by LeapTec.

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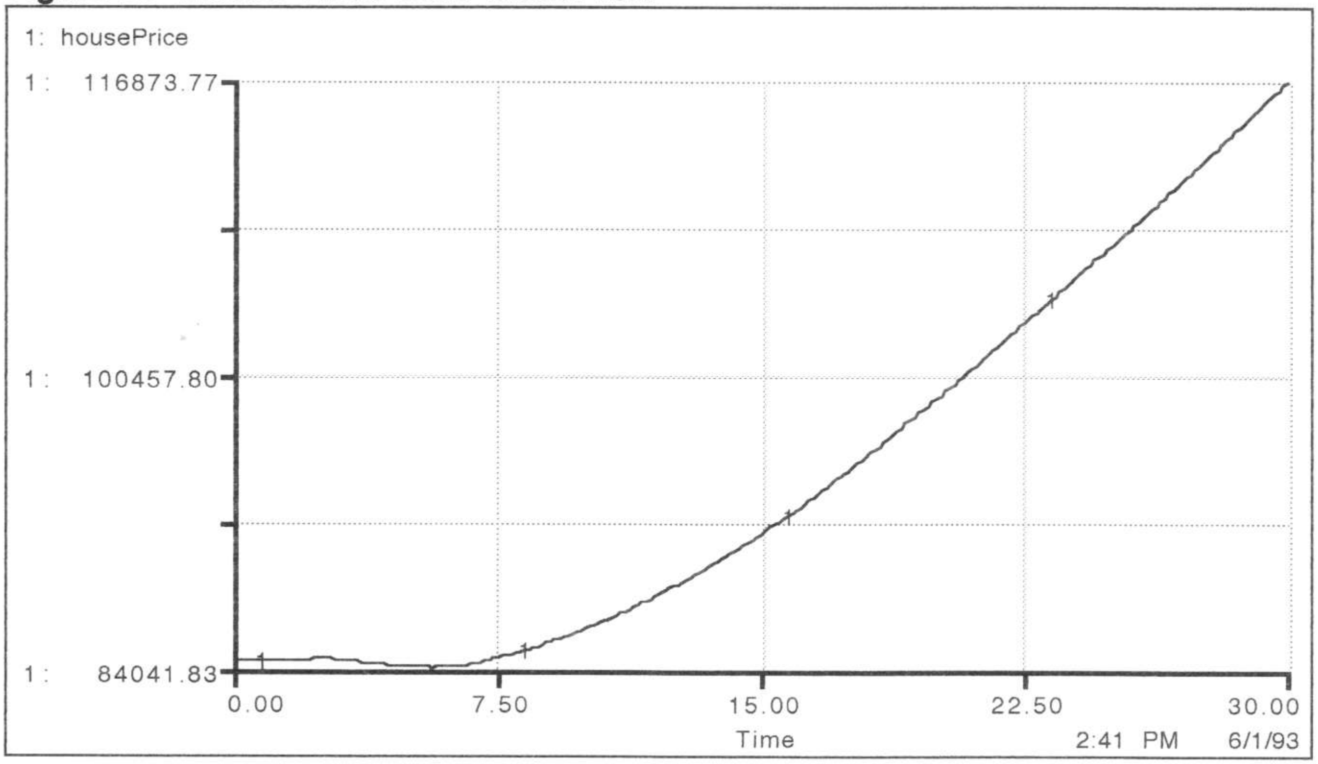
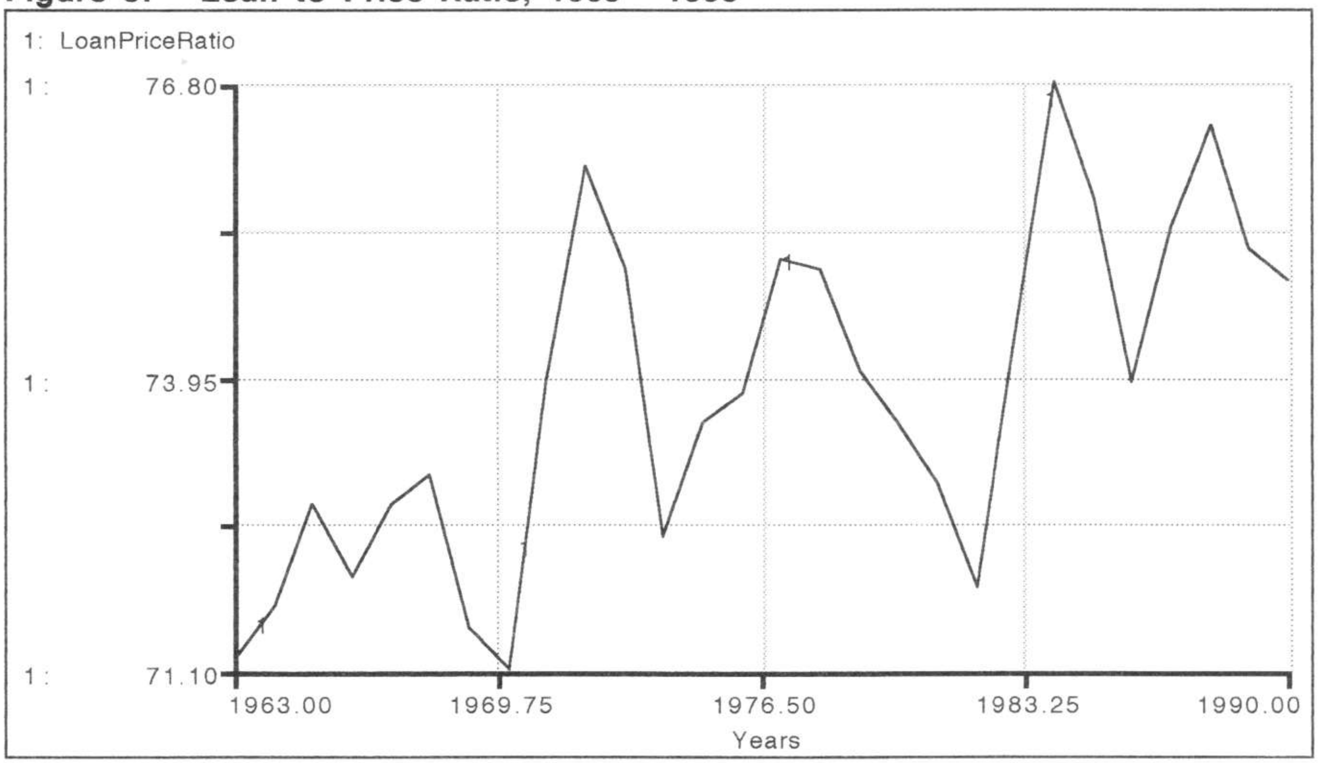
[4]House prices were deflated using the GNP implicit price deflator. A problem with using any generally available price index is that the index itself will include changes in the price of the good being deflated. Including the good in the price index will make the "real" price increase appear <u>less</u> dramatic if the price of the good in question has increased faster than other prices. For many uses, this is not a significant problem because the product in question represents only a small part of the price index. But, the price of housing may represent a large component of the price index. Hence the rise in "real" house prices shown in Figure 1 probably understates the actual rise.

Figure 2: House Price from model run



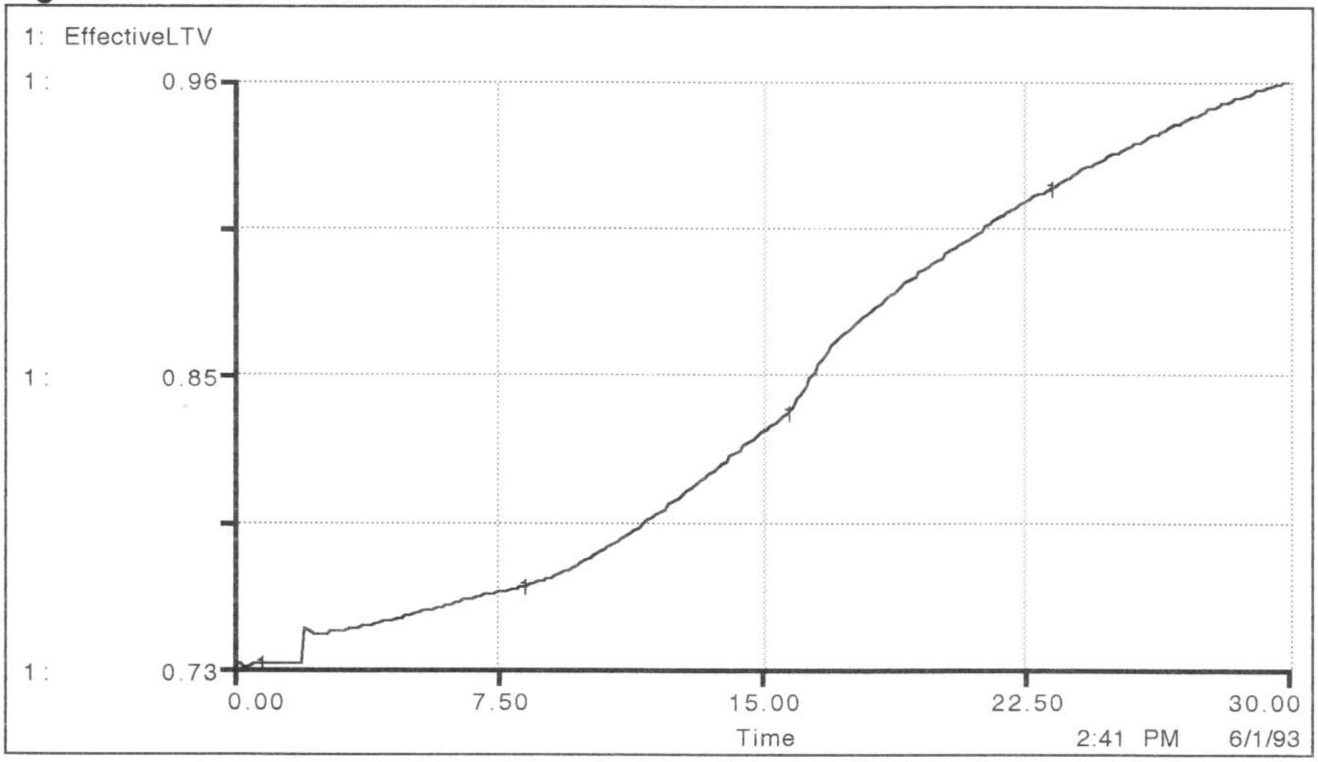
The LTV Ratio. (See Figure 4, LeapTec Report 1.4a, Figure 4, LeapTec Analytical Report "Lending Your Way Our of Problems, Report 2.1; Figure 3, LeapTec Analytical Report "Extrapolative Expectation in Financial Guarantee Programs", Report 2.2; Figure 3 LeapTec Analytical Report "GBE Competition: Credit Standards and Purchasing Your Way Out of Problems", Report 2.3; Figure 2, "Expanding the Boundaries of Federal Loan Insurance Programs", Report 2.4.). Figures 3 and 4 below show the loan to value ratio. Figure 3 is a time series from the real world; Figure 4 is a time series simulated by the model. Both show rising LTV. The real data is more variable. The model output rises higher.

Figure 3: Loan to Price Ratio, 1963 - 1990



Source: *Rates & Terms on Conventional Home Mortgages,* Federal Housing Finance Board, 1990, Table 3, Terms on Conventional Single Family Mortgages: Annual National Averages, Previously Occupied Homes. Data plot by LeapTec.

Figure 4: EffectiveLTVRatio from model run



Real Mortgage Debt. (Figure 10, Report 1.4a). Figures 5 and 6 below show real (i.e. deflated) mortgage debt. Figure 5 (real world data) and Figure 6 (model output) both show rising debt. The model starts at a much higher value (but one must be careful in comparing price levels). Figure 6, for model output, also shows the components of deflated mortgage debt -- the originators portfolio and the GBE's portfolio. We did not have data in our reports on these components in a deflated form. However we did show plots for nominal and percentage values for some of these quantities. (See Figure 16, Report 1.4a and Figure 2, LeapTec Analytical Report "Lending Your Way Our of Problems, Report 2.1.) And we reproduce that figure below as Figure 7, for the convenience of the reader. The nominal data (Figure 7) shows the emergence of the GBEs as important players, and so does the model data.

Figure 5. Mortgage Debt Outstanding on Non-Farm 1-4 Family Homes, 1963-1990, in constant dollars.

Source: Data plot by LeapTec from Table B-3 Implicit price deflators for gross national product, 1929 - 1990 and Table B-73, Mortgage debt outstanding by type of property and financing, 1939 - 1990 from the Economic Report of the President, February 1991.

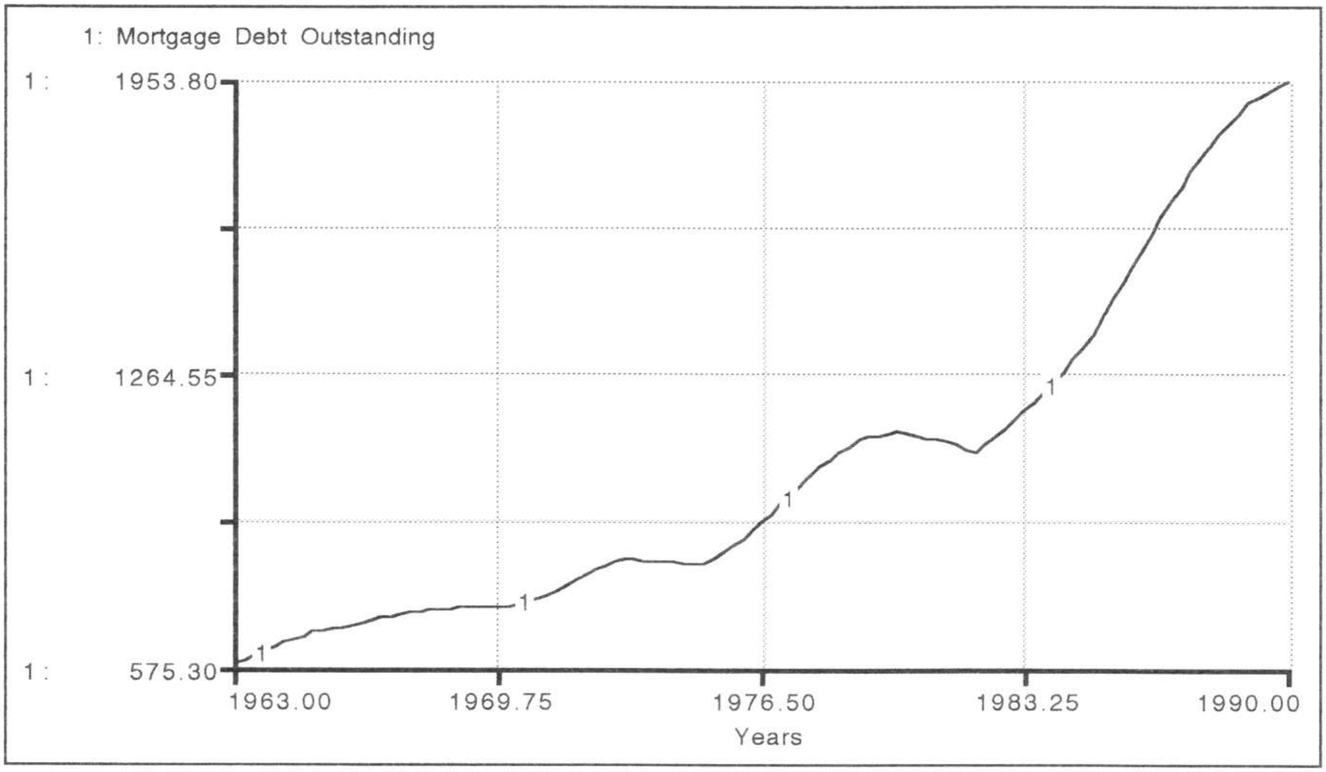
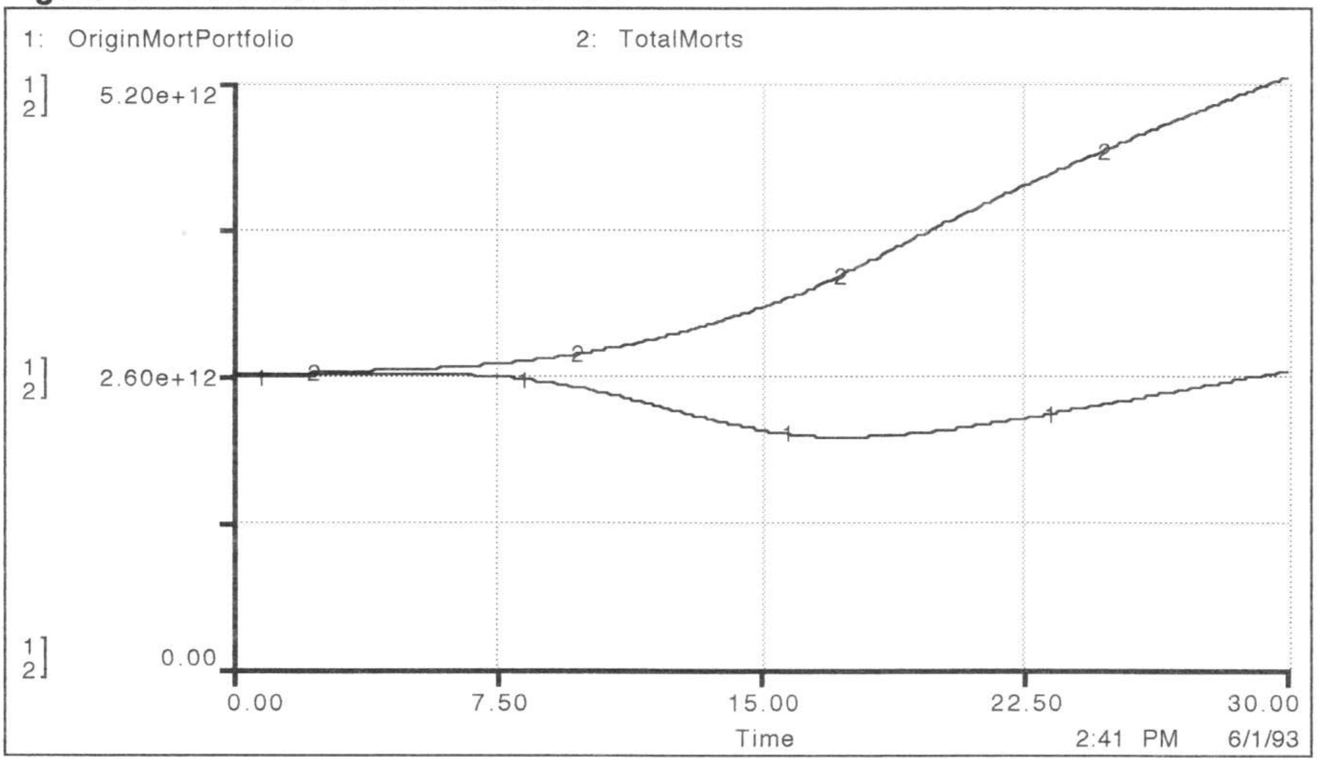


Figure 6: TotalMorts from model run



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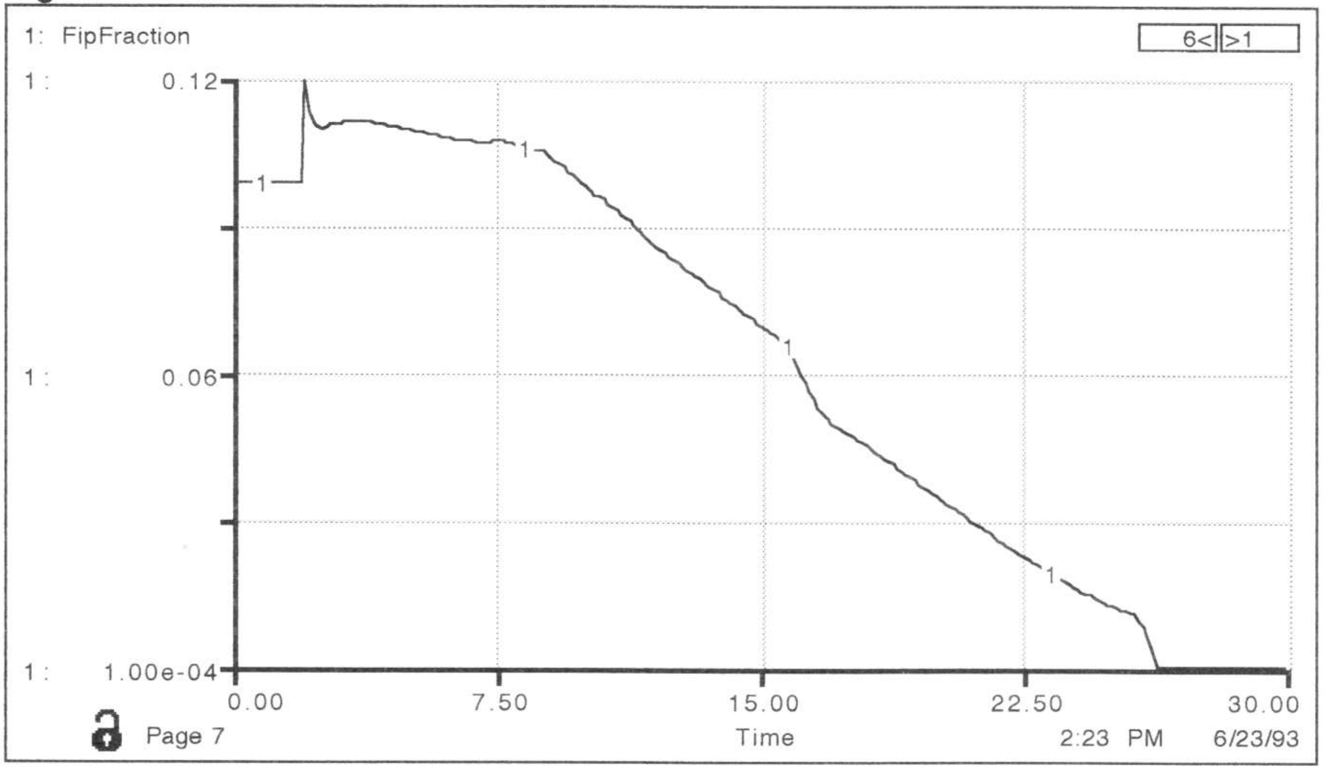
Federal Loan Insurance Program Fraction of Originations. (See Figure 24 of LeapTec Report "Designing New Federal Financial Guarantee Programs). Figure 8 (real world data) and Figure 9 (model output) below show the fraction of originators insured by Federal Loan Insurance Programs. Both figures show a decline in the fraction of loans insured. The data starts higher, drops earlier and is more variable.

Figure 8: Fraction of Loan Originations Insured By FHA & VA
Source: Revised annual data from Survey of Mortgage Lending Activity, Financial Services Division, HUD. Data for 1990 & 1991 is preliminary and subject to revision. Data plot by LeapTec.

Figure 9: FIPFraction from model run



Credit standards of Federal Loan Insurance Program (FIP) (see Figure 5 and footnote 7, "Expanding the Boundaries of Federal Loan Insurance Programs" in Report 2.4). Figure 10 shows data on the FHA's Housing expense ratio, and Figure 9 shows a simulated time series of the housing expense ratio of the modeled Federal Loan Insurance Program (FIP). Both figures show a rise, and decline. The model shows a more severe decline.

Figure 10: FHA's Housing Expense Ratio.

Source: Compiled by GAO from annual issues of *Characteristics of FHA Single-Family Mortgages: Selected Sections of National Housing Act,* U. S. Department of Housing and Urban Development, 1978 - 1991, and *Series Data Handbook, A supplement to FHA Trends Covering Home Mortgage Characteristics,* Department of Housing and Urban Development, 10/12/78, for data from 1960 through 1977. Definition of the Housing Expense Ratio was revised in 1977 and 1988 by HUD. From 1960 through 1978: "Monthly housing expense to total effective income"; from 1978 through 1988: "Total housing expense to total effective income"; From 1988 through 1991: "Total mortgage payment to total effective income". The dotted box highlights periods in which the ratios are calculated on different bases. Data plot by LeapTec.

Figure 11. FIPHER from model run

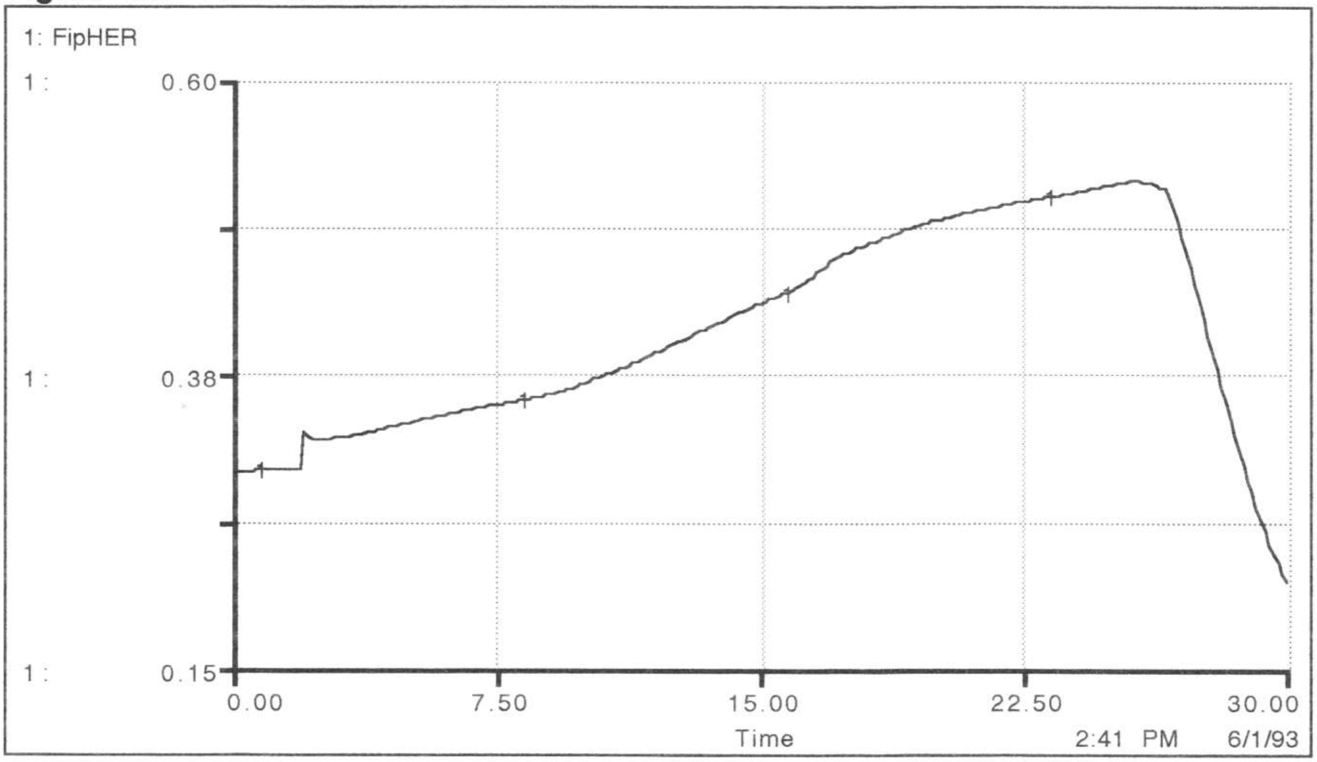
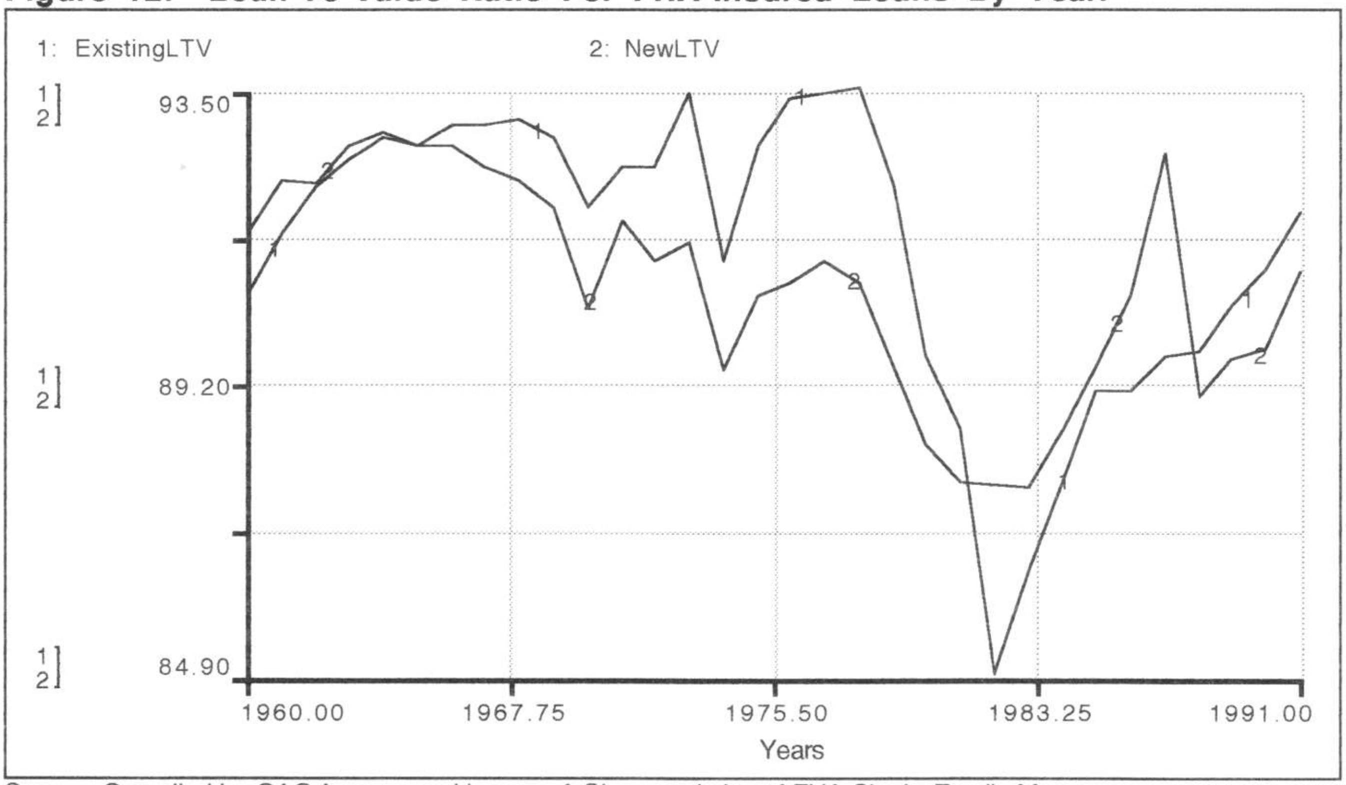


Figure 12 shows data on the FHA's Loan To Value Ratio. Figure 13 shows a simulated time series for the Loan To Value ratio of the model's Federal Loan Insurance Program (FIP). The data and the simulated time series both show a small rise followed by a decline. The model declines much further. The data shows an upturn at the end.

Figure 12: Loan-To-Value Ratio For FHA-Insured Loans By Year.



Source: Compiled by GAO from annual issues of *Characteristics of FHA Single-Family Mortgages: Selected Sections of National Housing Act,* U. S. Department of Housing and Urban Development, 1978 - 1991, and *Series Data Handbook, A Supplement to FHA Trends Covering Home Mortgage Characteristics,* Department of Housing and Urban Development, 10/12/78, for data from 1960 through 1977. The dotted box highlights periods in which the ratios are calculated on different bases. Data plot by LeapTec.

See also Footnote 2 to Steven Langley's memo of 1/5/93 "Average FHA sec. 203 (b) loan-to-value ratio (ltv) from 1960 to 1991 for single family homes" in the "Modeling Notes" section of LeapTec Report 2.4, *Expanding the Boundaries of Federal Loan Insurance Programs.*

Figure 13: FIPLTV from model run