EVALUATION OF THE BENEFITS FROM USING SYSTEM DYNAMICS ON PERSONAL COMPUTERS FOR CORPORATE FINANCIAL MANAGEMENT

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ABSTRACT.

DYNAMO has been used for many years on mainframe computers. Like many other applications programs and computer languages, it has been made available on Personal Computers. Will that make System Dynamics easily available to many potential users who never tried to use it on mainframes? Does one need to be an Information System specialist to use DYNAMO on a PC?

These are the questions to which this paper intents to give an answer to. Subsequently, we used DYNAMO on a PC for a very simple financial application, and compared it superficially with the (already) traditional approach of spreadsheets.

INTRODUCTION.

Having used different versions of DYNAMO on an IBM S/370 several years ago and having had to stop any Systems Dynamics activity for a while, we thought it would be interesting to verify if the recent technological evolution (hardware and software) would allow new users to easily access the DYNAMO language.

In particular, we were interested by the use of DYNAMO on PCs, and by its comparison with other PC tools, like the spreadsheet; we therefore took a very simple example of financial management, not usually handled using System Dynamics.

We shall first of all evaluate the DYNAMO language when used on a PC; and then apply it to a simple financial model, and compare it to a well known spreadsheet.

1. THE PROFESSIONAL DYNAMO (PD) FOR PC.

Having contacted Pugh-Associates Inc, in the USA, in October 1985, we decided to order a copy of the Professional Dynamo ($500), the Professional Dynamo Plus ($2000) being too expensive for the limited experiment we wanted to perform; the description of the additional functions of the PD+ versus those of the PD did not give us the impression to justify the price differential.

The PD version 1.3 arrived from the USA in February 1986. Here are our observations, which we subdivided into comments on the package, comments on the easiness of installation and use, and comments on the accompanying documentation.

THE PD VERSION 1.3 PACKAGE.

The package that came was made of:

- 2 diskettes: one contains the main program , the other one the supplemental programs; the minimum PC configuration is 256K of RAM memory; the math co-processor is not necessary, but used when it exists
- a manual, that contains the User's Manual and the Reference Manual; this manual is entitled "draft version 1.3", showing that it is not the definitive manual
- the Reference card is said to accompany, but does not!!

EASINESS OF INSTALLATION AND USE:

1. installing the PD either on diskettes or on a hard disk is rather simple; the User's Manual explains how to do it; the user has the right to make 2 copies of the original diskettes; the procedure used combines programs from both diskettes into a working diskette, and decreases a counter for every installation, so that the user could not make more than 2.

   Particularly interesting, and not existing (yet) for many PC SW nowadays, is the possibility to "uninstall" PD from either a diskette or a hard disk: when something goes wrong during the PD installation, or when the user

whishes to use a hard disk instead of a diskette (or vice versa) and has already installed the program twice, he/she may "uninstall" it, which increases the counter by one unit again!

Our only remark about the installation is that users generally place the software diskette in disk drive A: and the data diskettes in drive B: meanwhile the PD procedure suggests that the PD working diskette should be placed in drive B: and the data diskette in drive A:

2. the command menu (and subcommands menus) works pretty much like the LOTUS one(s): move the cursor on the desired command and press the Enter key, or just press the first letter of the desired command name; PD is clever enough to anticipate what the next command will be, and automatically moves the cursor to it: after editing a model, it is usual to compile it, then simulate and look at the results!

3. five commands are offered on the PD main menu:

   - EDIT, used to enter or modify a model, or a file with the desired output specifications (tables and graphs)
   - COMPILE, used to compile the program and check syntax and missing specifications; if the compilation may not be achieved correctly, the model is automatically edited for modifications
   - SIMULATE, used to run the model once or several times, a subcommand giving the user the opportunity to change parameters for more runs
   - REPORT (sometimes referred to as VIEW in the litterature), shows on the screen or prints on the Graphics printer the desired output
   - DOCUMENT appears on the menu, but is not available in version 1.3!!
   - HELP

   A tutorial is contained in the User's Manual, which is very good at helping the beginner to get trough the different commands and PD phases.

4. the utilization of the PD program itself proved to be very easy, at least for somebody already used to work with a PC; but the menu approach would not create any problem to a PC beginner, in our opinion.

5. the SIMULATE command was a bit confusing, because it does not simulate immediately: it offers the possibility to change some parameters, even when coming directly from COMPILE

6. REPORT produces tables and graphs which are not different from the ones known for many years now on the mainframe versions of DYNAMO; PD does not take advantage of the PC possibilities to offer a clearer output, which is disappointing. The PD+ version (4 times more expensive) is said to offer a better output, but we did not get a chance to test it

7. PD files: PD creates different types of files at every step of its use:

   - EDIT is used to create or update *.DYN files (the models) and/or *.DRS files (display specifications: print and plot requirements)
   - COMPILE reads *.DYN files and creates 3 types of files: *.SMT, *.DAT and *.INS which will be used by SIMULATE
   - SIMULATE uses the files created by COMPILE, and produces *.RSL files containing the results of the simulation; it also creates *.STT files when using the Preserve/Resume possibility (to start a new simulation from where the previous one stopped)
   - REPORT uses the *.DRS files (display specifications) and applies their content to the *.RSL files to produce tables and plots
   - DOCUMENT is not available in this version of PD

8. only models (*.DYN) and display specifications (*.DRS) files may be edited, which prevents the user from developping his/her own pieces of programming (e.g. plotter output, better table presentation, ..).

THE DOCUMENTATION.

The manual(s) is really a draft; figures are not clean, and the PD Reference Manual part is far from being complete: only chapters 3, 4, 6, 7 and 8 exist; the last chapters' pages are mixed up!! Not easy to find your way. Error messages are not explained yet in this version.

THE PD V 1.4 PACKAGE.

In April 1986, we received the PD version 1.4: 2 new diskettes, and a new (draft) of the User's Manual and Reference Manual. At the same time, Pugh-Associates Inc was asking to send back the original diskettes of version 1.3

From the accompanying letter, we understood that version 1.4 includes new features, and that the documentation is now 90% complete.

At first, we were unable to install version 1.4 following the instructions of the Manual; having contacted Pugh-Associates Inc, it seemed that this was happening with some PCs and not with others! The problem is in relation with the protection scheme of the package: the SIMULATE module is hidden from the DOS, and sometimes the commands issued from a Menu do not find it! To make it more positive, we experimented here how interesting the "uninstall" procedure is!

While waiting for a solution (or just an answer about what to do in order to use the PD V 1.4), we had a quick look at the new (draft) Manual: it shows indeed a real progress in the amount of available documentation, but the last chapters (altough different from the 1.3 version) are consistently mixed up!! Page 10-4 is followed by the end of Chapter 15, of which the first page is followed by the last one of Chapter 14, etc... until page 10-6 and 10-5 ends the Manual.

Beginning of June 1986, another call to the USA allowed us to understand that the problem we had would be solved if we were using DOS 3.0 or above! And it does, indeed! But how many weeks lost because of this!

EASINESS OF INSTALLATION AND USE:

1. The PD V 1.4 comes like V 1.3, on 2 diskettes; its installation does not offer any difficulty; the user has the right to only one copy this time; although the messages on the screen during installation time say one may install 2 copies, the counter goes down to 0 after the very first installation (2-1=0!). In conformity with the manual...

2. the modules are about the same as in V 1.3, with the following differences:

   - the *.DYN file does not have any more to specify "print" and "plot" requirements; all variables listed in the SAVE statement(s) are auto-

matically candidates for prints and plots; this means that *.DRS are not necessary any more

- REPORT is replaced by VIEW, already mentioned in the V 1.3 Manual; VIEW offers much more flexibility than REPORT was:
  - PLOT selected variables: the user chooses among the complete list of saved variables; but there is still no plotter output! Graphics printers will only produce a hardcopy if the GRAPHICS command was called from DOS; one can plot several or all variables using the same scale
  - TABULATE: either all variables, or a selection; in this case only, the table is produced in the order of the selected variables
- DOCUMENT exists this time! but on a second diskette (created during installation); but when the command is invoked, PD says it does not find the module, and does not prompt the user to place the appropriate diskette in drive B: !! But the module is interesting: it allows the user to re-order his/her model in a much clearer and readable way; it helps the user convert models written for previous DYNAMO versions; it creates *.DOC files, and sometimes *.DEF files (for definition files)
- HELP: is context-sensitive; the COMPILE module has no Help; the SIMULATE module has one, but when invoked, the message "RUN.HLP missing" appears..... In fact, it is not copied on the working diskette during installation, because of insufficient space on the diskette...

3. when in EDIT, PD sends the user back to DOS when there are errors in the model (eg. "failure to recognize end of line"), without explanation.

4. no COMPILE error messages in the V 1.4 manual; one can read the errors at the bottom of the screen, using Alt-N to look at the next error message, but how interpret it without the appropriate Manual pages? In particular, having used EXP (for Expenses) as a variable name, no clear message said this was a protected name (for Exponential); the error messages were difficult to interpret.

5. no way to plot other plots than line charts (eg, bar or pie charts)

6. no way to write kind of an EXEC to reproduce a series of commands in a certain order.

7. in PD V 1.4, the print a PLOTfunction does not work: one has to use the Prt-Scr.

8. in SIMULATE, one can save different runs under different names; one can re-start from the end of a certain simulation, and continue it further using the Preserve/Resume function, which uses *.STT files.

9. in VIEW, views are numbered and may be called back just by specifying their number; but only as long as the VIEW is active; no possibility to save the views under a name for later usage

10. error messages in the 1.4 manual: only a few for EDIT; none for the other modules.

GENERAL COMMENTS AND CONCLUSIONS ABOUT PD.

Our limited experience with Professional Dynamo, V 1.3 as well as 1.4, does not allow us to formulate a definitive opinion, nor give a valuable advice on when and why use it. Nevertheless, we believe this PC software really opens the way to Systems Dynamics for a much larger number of potential users, even if they are not using the PC yet for other applications.

We are waiting for Version 1.5 (or 2.0?), whatever the name and number; it probably will be the definitive one, with all functions and the complete documentation. Its use will avoid some of the little problems we almost pioneered with the existing versions.

No doubt about the easiness to install and learn how to use PD versus the installation and learning process in order to use DYNAMO on a mainframe computer.

Looking at performances, one can already learn and develop medium size models on a usual PC, with 256K of memory and 2 floppy diskette drives! Of course, the use of more powerful PC models, in terms of memory size and instructions per second, allows the user to build much bigger models and process them with a still acceptable response time.

Our only regret is that PD does make full use of the PC possibilities which are usually used in all PC software, mainly in graphics (access to more than just line charts) and output (plotter output, and better control of all outputs: tables and graphs).

But this is said to exist in the PD+ package, which is unfortunately 4 times more expensive!

2. DYNAMO OR FINANCIAL PLANNING TOOLS FOR FINANCIAL MANAGERS?

A base model (Figure 1 on page 8) was written with PD, based on the following assumptions:

- a company has a revenue of 50 (whatever the monetary unit) and expects an annual increase of 25% over the 5 years of its strategic planning period
- its manufacturing cost is 19, and is likely to growth at 25% a year
- general expenses are 17, and would growth at 33% a year
- R&D expenses represent 4% of the revenue
- tax rate is 50% of EBIT (earnings before income taxes)

```
*
* revenue
*
l rev.k=rev.j+dt*revchg.jk
n rev=irev
c irev=50
r revchg.kl=rev.k/4
*
* cost
*
l cost.k=cost.j+dt*costchg.jk
n cost=icost
c icost=19
r costchg.kl=cost.k/4
*
* expenses
*
l gexp.k=gexp.j+dt*gexpchg.jk
n gexp=igexp
c igexp=17
r gexpchg.kl=gexp.k/3
*
* research & development
*
a rdexp.k=rev.k*.04
*
* earnings before tax
*
a ebit.k=rev.k-cost.k-gexp.k-rdexp.k
*
* provision for taxes
*
a tax.k=ebit.k*.50
*
* net profit
*
a profit.k=ebit.k-tax.k
*


save rev,cost,gexp,rdexp,ebit,tax,profit
save revchg,costchg,gexpchg
spec dt=1/length=5/savper=1
```

Figure 1. PD base model

The same model was also developped in LOTUS123.

There is no difficulty to use the PD for discrete financial planning as with existing and widely used tools such as LOTUS, etc... The equations have very simple forms (levels and rates).

The only problem is to put the value of the computation interval DT, which is specified in the SPEC equation, at the value of the period under consideration.

Moving from one unit time interval (such as year) to another time interval (such as months or quarters) must be done taking into consideration the discounted effect of another time unit. Example: 12% per year ; monthly rate is NOT 1%.....

A first simulation of MOD1 shows an increasing difference in the results between DYNAMO (Figure 2 on page 9) and LOTUS (Figure 3 on page 9)!!

A special attention must be put on the value of the relative error parameter (REL-ERR), which is set by default to 10E-3; this REL-ERR value enables the computer to execute the integration process with a variable step size under the Runge-Gutta method. Variable step integration generates an unfortunate discrepancy between the discrete financial planners results and the DYNAMO ones.

One has to give REL-ERR the value 0 to integrate with the Euler method, and so obtain results which are comparable with the discrete models. There is no other way of saving the REL-ERR value of 0 than entering its value in the SPEC statement of the model; otherwise, the default value is used everytime the SIMULATE function is called!!

mod1.rsl - Page 1 MOD1 Runge-Kutta

TIME	0.	1.	2.	3.	4.	5.
REV	50.	64.2	82.423	105.82	135.86	174.42
COST	19.	24.396	31.321	40.211	51.626	66.28
GEXP	17.	23.724	33.096	46.172	64.412	89.859
RDEXP	2.	2.568	3.2969	4.2328	5.4343	6.9768
EBIT	12.	13.512	14.709	15.204	14.385	11.305
TAX	6.	6.756	7.3546	7.6019	7.1925	5.6525
PROFIT	6.	6.756	7.3546	7.6019	7.1925	5.6525
REVCHG	12.5	16.05	20.606	26.455	33.964	43.605
COSTCHG	4.75	6.099	7.8302	10.053	12.906	16.57
GEXPCHG	5.6667	7.908	11.032	15.391	21.471	29.953

Figure 2. Model 1 - PD - Runge-Kutta

time	0	1	2	3	4	5
rev	50.00	62.50	78.13	97.66	122.07	152.59
cost	19.00	23.75	29.69	37.11	46.39	57.98
gexp	17.00	22.67	30.22	40.30	53.73	71.64
rdexp	2.00	2.50	3.13	3.91	4.88	6.10
EBIT	12.00	13.58	15.09	16.34	17.07	16.86
tax	6.00	6.79	7.55	8.17	8.54	8.43
profit	6.00	6.79	7.55	8.17	8.54	8.43
revchg	12.50	15.63	19.53	24.41	30.52	38.15
costchg	4.75	5.94	7.42	9.28	11.60	14.50
gexpchg	5.67	7.56	10.07	13.43	17.91	23.88

Figure 3. Model 1 - LOTUS

A second simulation was made, using the Euler method; the results are the same as with LOTUS (Figure 4 on page 10).

mod1.rsl - Page 1 MOD1 Euler

TIME	0.	1.	2.	3.	4.	5.
REV	50.	62.5	78.125	97.656	122.07	152.59
COST	19.	23.75	29.688	37.109	46.387	57.983
GEXP	17.	22.667	30.222	40.296	53.728	71.638
RDEXP	2.	2.5	3.125	3.9063	4.8828	6.1035
EBIT	12.	13.583	15.09	16.344	17.072	16.863
TAX	6.	6.7917	7.5451	8.1722	8.5362	8.4316
PROFIT	6.	6.7917	7.5451	8.1722	8.5362	8.4316
REVCHG	12.5	15.625	19.531	24.414	30.518	38.147
COSTCHG	4.75	5.9375	7.4219	9.2773	11.597	14.496
GEXPCHG	5.6667	7.5556	10.074	13.432	17.909	23.879

Figure 4. MOD 1 - PD - Euler

The next question is: what if the annual growth rates of revenue, costs and expenses are not constant? This is easy to tackle in a LOTUS model (Figure 5); PD may address the same problem using tables (Figure 6 on page 11 shows the model and Figure 7 on page 12 its results). The results are the same, if one uses the Euler integration method, of course....

time	0	1	2	3	4	5
rev	50.00	60.00	72.00	82.80	95.22	114.26
cost	19.00	23.75	28.50	34.20	39.33	45.23
gexp	17.00	22.10	27.63	34.53	41.44	49.73
rdexp	2.00	2.40	2.88	3.31	3.81	4.57
EBIT	12.00	11.75	12.99	10.76	10.64	14.74
tax	6.00	5.88	6.50	5.38	5.32	7.37
profit	6.00	5.88	6.50	5.38	5.32	7.37
revchg	12.50	15.00	18.00	20.70	23.81	28.57
costchg	4.75	5.94	7.13	8.55	9.83	11.31
gexpchg	5.67	7.37	9.21	11.51	13.81	16.57
trev	0.20	0.20	0.15	0.15	0.20	0.20
tcost	0.25	0.20	0.20	0.15	0.15	0.25
tgexp	0.30	0.25	0.25	0.20	0.20	0.20

Figure 5. LOTUS model with variable growth rates

```
*
* revenue
*
l rev.k=rev.j+dt*revpct.jk
n rev=50
r revpct.kl=rev.k*revchg.k
a revchg.k=table(trev,time.k,0,5,1)
t trev=.20/.20/.15/.15/.20/.20
*
* cost
*
l cost.k=cost.j+dt*costpct.jk
n cost=19
r costpct.kl=cost.k*costchg.k
a costchg.k=table(tcost,time.k,0,5,1)
t tcost=.25/.20/.20/.15/.15/.25
*
* expenses
*
l gexp.k=gexp.j+dt*gexppct.jk
n gexp=17
r gexppct.kl=gexp.k*gexpchg.k
a gexpchg.k=table(tgexp,time.k,0,5,1)
t tgexp=.30/.25/.25/.20/.20/.20
*
* research & development
*
a rdexp.k=rev.k*.04
*
* earnings before tax
*
a ebit.k=rev.k-cost.k-gexp.k-rdexp.k
*
* provision for taxes
*
a tax.k=ebit.k*.50
*
* actual net profit
*
a profit.k=ebit.k-tax.k

save rev,cost,gexp,rdexp,ebit,tax,profit
save revpct,revchg,costpct,costchg,gexppct,gexpchg
spec dt=1/length=5/savper=1
```

Figure 6. PD model with tables for variable growth rates

modlt.rsl - Page 1 MOD1T Euler

TIME	0.	1.	2.	3.	4.	5.
REV	50.	60.	72.	82.8	95.22	114.26
COST	19.	23.75	28.5	34.2	39.33	45.23
GEXP	17.	22.1	27.625	34.531	41.438	49.725
RDEXP	2.	2.4	2.88	3.312	3.8088	4.5706
EBIT	12.	11.75	12.995	10.757	10.644	14.739
TAX	6.	5.875	6.4975	5.3784	5.3218	7.3695
PROFIT	6.	5.875	6.4975	5.3784	5.3218	7.3695
REVPCT	10.	12.	10.8	12.42	19.044	22.853
COSTPCT	4.75	4.75	5.7	5.13	5.8995	11.307
GEXPPCT	5.1	5.525	6.9063	6.9063	8.2875	9.945

Figure 7. PD model with tables for variable growth rates

Although the PD has the capability to simulate all functions of the traditional discrete financial planners, its use is sometimes more tedious and cumbersome. Its main advantage therefore must be viewed in the enhanced possibility to connect (simulated) discrete financial planning models with general continuous corporate models such as strategic development ones.

In the next instance, we will add a few equations which will connect the traditional financial planner with a control equation relating the corporate financial results (profit after tax) with the R&D policy. The R&D expenses are viewed as creating after a given time lag new products and services which generate additional sales. The control policy of increasing the R&D effort takes into consideration the discrepancy between a given desired profit and the actual results.

In the design of the different continuous equations, one must remember that the value of the computing interval DT which has been set in the financial model to the value of the period under review, must as a rule of thumb not be smaller than the value of 1/2 the smallest delay.

So, let us now compare the 2 modelling systems if a feed-back is introduced in the model. Let us say that the company adopts a R&D policy that says that if the net profit after tax does not represent 15% of the revenue, the company has to invest more in R&D expenses: 80 cents for every $ that is missing in the net profit to reach the target! This would have an impact on the revenue, that would growth faster than planned, but with a delay of 3 years, because of the time lag between deciding to invest more in R&D and the possible effect of this decision on the revenue. Costs are also growing when producing more to sell more! General expenses are supposed to grow at their normal rate, without being impacted by this additional business.

This is done in MOD2 (Figure 8 on page 13 shows the model, and Figure 9 on page 14 its results); the equivalent LOTUS model is shown in Figure 10 on page 14.

```
*
* revenue
*
l rev.k=rev.j+dt*(revchg.jk+eard.jk/10)
n rev=50
r revchg.kl=rev.k*revpct.k
a revpct.k=tabhl(trev,time.k,0,5,1)
t trev=.20/.20/.15/.15/.20/.20
*
* cost
*
l cost.k=cost.j+dt*(costchg.jk+eard.jk/40)
n cost=19
r costchg.kl=cost.k*costpct.k
a costpct.k=tabhl(tcost,time.k,0,5,1)
t tcost=.25/.20/.20/.15/.15/.25
*
* expenses
*
l gexp.k=gexp.j+dt*gexpchg.jk
n gexp=17
r gexpchg.kl=gexp.k*gexppct.k
a gexppct.k=tabhl(tgexp,time.k,0,5,1)
t tgexp=.30/.25/.25/.20/.20/.20
*
* research & development
*
a rdexp.k=(rev.k*.04)+laard.k
*
* earnings before tax
*
a ebit.k=rev.k-cost.k-gexp.k-rdexp.k
*
* provision for taxes
*
a tax.k=ebit.k*.50
*
* actual net profit
*
a profit.k=ebit.k-tax.k
*
* desired net profit
*
a dprofit.k=rev.k*.15
*
* expected additional R&D expenses rate
*
r eard.kl=z*(dprofit.k-profit.k)
c z=.8
*
* actual additional R&D expenses rate
*
r aard.kl=delay3(eard.jk,3)
l laard.k=laard.j+dt*aard.jk
n laard=0


save rev,cost,gexp,rdexp,ebit,tax,profit,dprofit,eard,aard,laard
save revpct,revchg,costpct,costchg,gexppct,gexpchg
spec dt=1/length=5/savper=1/rel_err=0
```

Figure 8. Model 2 - PD - with feedback

mod2.rsl - Page 1 model 2

TIME	0.	1.	2.	3.	4.	5.
REV	50.	60.12	72.44	83.739	96.992	117.27
COST	19.	23.78	28.61	34.44	39.779	45.966
GEXP	17.	22.1	27.625	34.531	41.438	49.725
RDEXP	2.	3.6048	5.2976	6.9496	8.6797	12.451
EBIT	12.	10.635	10.907	7.818	7.0955	9.1281
TAX	6.	5.3176	5.4537	3.909	3.5478	4.5641
PROFIT	6.	5.3176	5.4537	3.909	3.5478	4.5641
DPROFIT	7.5	9.018	10.866	12.561	14.549	17.591
EARD	1.2	2.9603	4.3298	6.9215	8.8008	10.421
AARD	1.2	1.2	1.2	1.2	2.9603	4.3298
LAARD	0.	1.2	2.4	3.6	4.8	7.7603
REVCHG	10.	12.024	10.866	12.561	19.398	23.454
REVPCT	.2	.2	.15	.15	.2	.2
COSTCHG	4.75	4.756	5.722	5.166	5.9669	11.492
COSTPCT	.25	.2	.2	.15	.15	.25
GEXPCHG	5.1	5.525	6.9063	6.9063	8.2875	9.945
GEXPPCT	.3	.25	.25	.2	.2	.2

Figure 9. Model 2 - PD - with feedback

time	0	1	2	3	4	5
rev	50.00	60.12	72.44	83.74	96.99	117.27
cost	19.00	23.78	28.61	34.44	39.78	45.97
gexp	17.00	22.10	27.63	34.53	41.44	49.73
rdexp	2.00	3.60	5.30	6.95	8.68	12.45
EBIT	12.00	10.64	10.91	7.82	7.10	9.13
tax	6.00	5.32	5.45	3.91	3.55	4.56
profit	6.00	5.32	5.45	3.91	3.55	4.56
dprofit	7.50	9.02	10.87	12.56	14.55	17.59
eard	1.20	2.96	4.33	6.92	8.80	10.42
aard						
eard	1.20	2.96	4.33	6.92	8.80	10.42
aard	1.20	1.20	1.20	1.20	2.96	4.33
laard	0.00	1.20	2.40	3.60	4.80	7.76
trev	0.20	0.20	0.15	0.15	0.20	0.20
tcost	0.25	0.20	0.20	0.15	0.15	0.25
tgexp	0.30	0.25	0.25	0.20	0.20	0.20

Figure 10. Model 2 - LOTUS - with feedback

CONCLUSIONS

The use of Professional Dynamo, although it is not available yet in its definitive version, proved to be very easy and powerful; some minor improvements could be suggested, but we intend to wait for the next version before making any suggestion of any kind.

It certainly opens the use of Systems Dynamics to a lot of potential users, they be already PC users or not.

For financial management, the use of LOTUS or Professional Dynamo give the same results for the limited experiments we made with both systems. Financial managers are certainly more used to think in terms of discrete models, but when wishing to integrate their models into a larger one, or when wishing to expand the use of their models to more complex relations, Systems Dynamics might be much better than discrete approaches.

As an example, our Model 2 could be improved by including a set of equations that would suggest an optimum R&D policy, bringing progressively the actual profit at the level of the desired profit; of course, this would be a function of our simplification, i.e. that R&D is the only factor that allows to grow faster than the normal trend, inducing more revenue and more profit!