Appendices

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## Appendix A: Model Parameter Descriptions

The following three tables give a short description of the model input parameters. The first table describes parameters particularly relevant to high-cost locations. The next table describes parameters particularly relevant to low-cost locations, and the third table describes parameters mainly relevant for transfer of tasks and build-up of employees in low-cost locations.

### Appendix A, Table 1: Parameters mainly relevant to high-cost locations

<table>
<thead>
<tr>
<th>Parameter (and Units)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INI TOTAL FTE HC (Person)</td>
<td>Number of R&amp;D employees in High Cost locations (new + rookies + experienced by Year end 2004)</td>
</tr>
<tr>
<td>HC QUIT FRACTION (1/Month)</td>
<td>The fraction of people quitting HC locations (internal rotation in the company not included)</td>
</tr>
<tr>
<td>HC TRAINING TIME (Month)</td>
<td>Training time (basic new-hire training)</td>
</tr>
<tr>
<td>HC TRAINING COST (EUR/(Person*Month))</td>
<td>Basic new-hire training costs per person per month</td>
</tr>
<tr>
<td>HC ROOKIE TIME (Month)</td>
<td>On-the-job training</td>
</tr>
<tr>
<td>HC ROOKIE PRODUCTIVITY (Dimensionless)</td>
<td>Productivity factor for Rookies in HC (Rookies are inexperienced and therefore have reduced productivity)</td>
</tr>
<tr>
<td>INI HC AVERAGE PERSON COSTS (EUR/(Person*Month))</td>
<td>Total cost (including travel, rent, licenses etc.) allocated per HC FTE by Year-end 2004. Salaries are only XX% of this</td>
</tr>
<tr>
<td>HC PERSON COST INCREASE RATE (1/Month)</td>
<td>Increase rate in HC person costs</td>
</tr>
<tr>
<td><strong>Parameter (and Units)</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>INI TOTAL FTE LC (Person)</td>
<td>Number of R&amp;D employees in Low Cost locations (new + rookies + experienced by Year-end 2004)</td>
</tr>
<tr>
<td>LC QUIT FRACTION (1/Month)</td>
<td>Fraction of people leaving LC locations</td>
</tr>
<tr>
<td>LC TRAINING TIME (Month)</td>
<td>Training time for the basic training of newly hired employees (classroom training)</td>
</tr>
<tr>
<td>LC TRAINING COST (EUR/(Person*Month))</td>
<td>Basic training cost for newly hired employees (per person per month)</td>
</tr>
<tr>
<td>LC TOTAL ROOKIE TIME (Month)</td>
<td>Time spent on on-the-job training after finished classroom training. This includes both the time as normal rookie and the time as hand-over rookie</td>
</tr>
<tr>
<td>LC ROOKIE PRODUCTIVITY (Dimensionless)</td>
<td>Productivity factor for Rookies (although only in the part of the time NOT used to hand over tasks)</td>
</tr>
<tr>
<td>INI LC AVERAGE PERSON COSTS (EUR/(Person*Month))</td>
<td>Total cost (excluding travel) allocated to LC FTE by Year-end 2004. Salaries are only XX% of this. The cost will grow with the rate below</td>
</tr>
<tr>
<td>LC PERSON COST INCREASE RATE (1/Month)</td>
<td>Increase rate in LC person cost</td>
</tr>
<tr>
<td>LC ONGOING TRAVEL COST (EUR/(Person*Month))</td>
<td>Average Travel + Hotel + Rented cars etc. for all LC employees</td>
</tr>
<tr>
<td>LC PRODUCTIVITY REDUCTION (Dimensionless)</td>
<td>Productivity reduction due to low average experience (1-2 years in LC vs. 5-10 years in HC)</td>
</tr>
</tbody>
</table>

Appendix A, Table 2: Parameters mainly relevant to low-cost locations
<table>
<thead>
<tr>
<th>Parameter (and Units)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>REPLACEMENT IN HC VS. LC (Dimensionless)</td>
<td>Factor for how many of HC quit who will be replaced in HC. When a person leaves a high-cost location, the job is either given to a new-hired employee, or (when replacement rate lower than 1) the job is given to an employee who has transferred his or her job to a low-cost location. The replacement rate is only below 1 for a limited period of time (to finance the initial build up in low-cost locations).</td>
</tr>
<tr>
<td>ADDITIONAL GROWTH (Dimensionless)</td>
<td>Factor for the ramp-up of productive LC employees (fixed for the first period, then gradually decreasing to zero after the 36th month)</td>
</tr>
<tr>
<td>HAND-OVER FRACTION OF LC ROOKIE TIME (Dimensionless)</td>
<td>The fraction of the time a newly hired LC Rookie spends on hand-over tasks (as opposed to normal rookie on-the-job training). Example: if the parameter is 1/3, and the total LC Rookie time is 6 months, an LC New Hire will after finished classroom training spend 2 months as Hand-Over-Rookie (with zero productivity), and 4 months as “normal rookie” (with the normal LC ROOKIE PRODUCTIVITY).</td>
</tr>
<tr>
<td>LC HANDOVER TRAVEL COST (EUR/(Person*Month))</td>
<td>Travel costs related to hand-over, i.e. only effect hand-over fraction of Rookies.</td>
</tr>
<tr>
<td>HC CAPACITY USE ON LC TRAINING (Dimensionless)</td>
<td>1-on-1 hand-over will result in XX% reduction of the HC employee’s productive time (LC employee will have 0 productivity)</td>
</tr>
</tbody>
</table>

Appendix A, Table 3: Parameters mainly relevant for transfer of tasks and build-up of employees in low-cost locations
Appendix B: Model Equations

The two following tables give an overview of the significant equations in the model. The first table describes the main equations for the rates influencing stock levels, and the next table describes the main equations for calculation of the monthly production, and well as monthly costs. After the two tables, a complete list of model equations is to be found.

### Main equations for the rates influencing stock levels

<table>
<thead>
<tr>
<th>Equation</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>HC hire = HC quits * REPLACEMENT IN HC VS. LC</td>
<td></td>
</tr>
<tr>
<td>LC replacement hire = LC quit</td>
<td></td>
</tr>
<tr>
<td>Comment: This hiring only compensates for the employee turn-over</td>
<td></td>
</tr>
<tr>
<td>LC new hire =</td>
<td></td>
</tr>
<tr>
<td>+ Productive FTE LC*ADDITIONAL GROWTH</td>
<td></td>
</tr>
<tr>
<td>+ LC replacing HC quit</td>
<td></td>
</tr>
<tr>
<td>Comment:</td>
<td></td>
</tr>
<tr>
<td>LC replacing HC quit = HC quit – HC hire</td>
<td></td>
</tr>
</tbody>
</table>

The rates between stages are calculated as delay-functions of the inflow-rates. For the training period, a high-order delay was used to imitate a pipeline delay, as this is a fixed period of time for each employee. For the period as a Rookie, a lower order delay was used, to reflect the variability in the learning curve for individuals.
### Main equations for production per month and cost per month

<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handover capacity reduction =</td>
<td>H-O-R FTE LC * HC capacity use on hand-over</td>
</tr>
<tr>
<td>Comment:</td>
<td>Each H-O-R (Hand-Over-Rookie) in a low-cost location will need physically to sit together with the person from whom he or she is taking over tasks. For this reason, the experienced person in the high-cost location will have reduced capacity (an average stipulated in the parameter: HC capacity use on hand-over)</td>
</tr>
</tbody>
</table>
| Productivity per month =                     | + Productive FTE HC  
+ HC ROOKIE PRODUCTIVITY*Rookie FTE HC  
- handover capacity reduction  
+ Productive FTE LC*(1-LC PRODUCTIVITY REDUCTION)  
+ LC ROOKIE PRODUCTIVITY*Rookie FTE LC  |
| Comments:                                    | 1) Unit of productivity is person/month (the case company often uses man-year, man-month or man-days as unit for projects or production)  
2) Number of productive days in LC higher than in HC. This is not included in the model, but “equals out” with coordination overhead |
| Cost per month =                              | +HC person cost*total FTE HC  
+New hired FTE HC*HC TRAINING COST  
+(LC person cost+LC ONGOING TRAVEL COST)*total FTE LC  
+New hired FTE LC*LC TRAINING COST  
+handover travel costs  |
| Comment:                                     | HC person costs and LC person costs develop over time with the person cost increase rate. In Vensim this is can be managed by treating person costs as stocks:  
input rate = PERSON COST INCREASE RATE*LC person cost  
(an initialized with the initial values of the person costs) |
Starting below is a complete list of the model equations from the case study model. According to the agreement with the case study company, the most confidential numbers (such as average employee costs etc.) have been made unrecognizable, through having ‘NN’ replacing the first digits. A number of the parameters do not relate directly to the model, but serve the purpose of producing nice output graphs.

List of equations (generated in Vensim):

**Formulas**

<table>
<thead>
<tr>
<th>Formula</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADDITIONAL GROWTH=</td>
<td>Dmnl</td>
</tr>
<tr>
<td>(0.03*PULSE(0, 61)</td>
<td></td>
</tr>
<tr>
<td>+RAMP(-0.03/36, 12, 48))</td>
<td></td>
</tr>
<tr>
<td>LC new hire=</td>
<td>Person/Month</td>
</tr>
<tr>
<td>+(Productive FTE LC*ADDITIONAL GROWTH)</td>
<td></td>
</tr>
<tr>
<td>+LC replacing HC quit</td>
<td></td>
</tr>
<tr>
<td>+&quot;HC micro-site optim.&quot;</td>
<td></td>
</tr>
<tr>
<td>+&quot;LC micro-site optim.&quot;</td>
<td></td>
</tr>
<tr>
<td>INI LC AVERAGE PERSON COST=</td>
<td></td>
</tr>
<tr>
<td>NN000/12</td>
<td>EUR/(Person*Month)</td>
</tr>
<tr>
<td>LC PERSON COST INCREASE RATE=</td>
<td>1/Month</td>
</tr>
<tr>
<td>+(LN(1.15)/12)*PULSE(0, 24)</td>
<td></td>
</tr>
<tr>
<td>+(LN(1.1)/12)*PULSE(24, 36)</td>
<td></td>
</tr>
<tr>
<td>LC person cost= INTEG (</td>
<td>EUR/(Month*Person)</td>
</tr>
<tr>
<td>+LC PERSON COST INCREASE RATE*LC person cost,</td>
<td></td>
</tr>
<tr>
<td>INI LC AVERAGE PERSON COST)</td>
<td></td>
</tr>
</tbody>
</table>
"HC job-trained"=
\[-\text{DELAY N}(\text{HC trained, HC ROOKIE TIME,}
\text{Rookie FTE HC/HC ROOKIE TIME, 3})\]\quad \text{Person/Month}

Productive FTE HC= \text{INTEG (}
\quad +"HC job-trained"-HC quit-"HC micro-site optim.",
\quad \text{INI TOTAL FTE HC/}
\quad (1+(\text{HC ROOKIE TIME}+\text{HC TRAINING TIME})\times \text{HC QUIT FRACTION}))\quad \text{Person}

"LC repl. hire"=
\[-\text{LC quit}\]\quad \text{Person/Month}

LC 2a=
\[-\text{DELAY N}(
\quad ("LC repl. hire"),
\quad \text{LC TRAINING TIME,}
\quad (\text{New hired FTE LC/LC TRAINING TIME})
\quad , 12)\]\quad \text{Person/Month}

LC 1a=
\[-\text{DELAY N}(
\quad \text{LC new hire,}
\quad \text{LC TRAINING TIME,}
\quad 0, 12)\]\quad \text{Person/Month}

New hired FTE LC= \text{INTEG (}
\quad +"LC repl. hire"+\text{LC new hire}
\quad -\text{LC 2a}-\text{LC 1a,}
\quad \text{LC TRAINING TIME/}
\quad (\text{LC TRAINING TIME}+\text{LC TOTAL ROOKIE TIME})
\quad \times \text{INI TOTAL FTE LC/}
\quad (1+1/((\text{LC TRAINING TIME}+\text{LC TOTAL ROOKIE TIME})
\quad \times \text{LC QUIT FRACTION})))\quad \text{Person}

cost per month=
\quad +\text{HC person cost}\times \text{total FTE HC}
\quad +\text{New hired FTE HC}\times \text{HC TRAINING COST}
Appendix B

\[(\text{LC person cost} + \text{LC ONGOING TRAVEL COST}) \times \text{total FTE LC} \]
\[+ \text{New hired FTE LC} \times \text{LC TRAINING COST} \]
\[+ \text{handover travel costs} \quad \text{EUR/Month} \]

Rookie FTE LC = \text{INTEG (}
\[+ \text{ LC 2a} \]
\[+ \text{ LC 1b} \]
\[- \text{ LC 2b-LC 1c}, \]
\[\text{LC TOTAL ROOKIE TIME/} \]
\[\text{(LC TRAINING TIME+LC TOTAL ROOKIE TIME)} \]
\)* \text{INI TOTAL FTE LC/} \]
\[\text{(1+(1/((LC TRAINING TIME+LC TOTAL ROOKIE TIME)}} \]
\[* \text{LC QUIT FRACTION)))) \quad \text{Person} \]

LC 2b =
\[\text{DELAY N(LC 2a, LC TOTAL ROOKIE TIME,} \]
\[\text{Rookie FTE LC/LC TOTAL ROOKIE TIME, 3) \quad \text{Person/Month} \]

Productive FTE LC = \text{INTEG (}
\[+ \text{LC 2b+LC 1c} \]
\[-"\text{LC micro- site optim."-LC quit,} \]
\[\text{INI TOTAL FTE LC/} \]
\[\text{(1+(LC TOTAL ROOKIE TIME+LC TRAINING TIME)*LC QUIT FRACTION))} \quad \text{Person} \]

"H-O-R FTE LC" = \text{INTEG (}
\[\text{LC 1a-LC 1b, 0) \quad \text{Person} \]

LC 1b =
\[\text{DELAY N(LC 1a, LC TOTAL ROOKIE TIME*} \]
\["\text{HAND-OVER FRAKTION OF LC ROOKIE TIME", 0, 12) \quad \text{Person/Month} \]

LC 1c =
\[\text{DELAY N(LC 1b, LC TOTAL ROOKIE TIME*} \]
\[(1-"\text{HAND-OVER FRAKTION OF LC ROOKIE TIME"}, 0, 3) \quad \text{Person/Month} \]

LC QUIT FRACTION =
\[0.07/12 \quad \text{1/Month} \]
handover capacity reduction=
"H-O-R FTE LC"*"HC CAPACITY USE ON HAND-OVER" Person

handover travel costs=
"H-O-R FTE LC"*"LC HAND-OVER TRAVEL COST" EUR/Month

total FTE LC=
New hired FTE LC+Productive FTE LC
+Rookie FTE LC+"H-O-R FTE LC" Person

LC TOTAL ROOKIE TIME=
6 Month

production per month=
(+Productive FTE HC
+HC ROOKIE PRODUCTIVITY*Rookie FTE HC
- handover capacity reduction
+((1-LC PRODUCTIVITY REDUCTION)*Productive FTE LC)
+LC ROOKIE PRODUCTIVITY*Rookie FTE LC)
*make unit per month Person/Month

"HAND-OVER FRAKTION OF LC ROOKIE TIME"=
0.333 Dmnl

output old year cost=
+IF THEN ELSE(Time=4, Nice Graph Year Cost/TIME STEP, 0)
+IF THEN ELSE(Time=16, Nice Graph Year Cost/TIME STEP, 0)
+IF THEN ELSE(Time=28, Nice Graph Year Cost/TIME STEP, 0)
+IF THEN ELSE(Time=40, Nice Graph Year Cost/TIME STEP, 0)
+IF THEN ELSE(Time=52, Nice Graph Year Cost/TIME STEP, 0)
+IF THEN ELSE(Time=64, Nice Graph Year Cost/TIME STEP, 0) EUR/Month
input year cost=
  +IF THEN ELSE(Time=0, cost per month*12*STY month/TIME STEP, 0)
  +IF THEN ELSE(Time=12, Year cost/TIME STEP, 0)
  +IF THEN ELSE(Time=24, Year cost/TIME STEP, 0)
  +IF THEN ELSE(Time=36, Year cost/TIME STEP, 0)
  +IF THEN ELSE(Time=48, Year cost/TIME STEP, 0)        EUR/Month

Nice Graph Year Cost= INTEG (input year cost-output old year cost, 0)  EUR

adding=
  production per month*1/12          Person/Month

summing=
  cost per month                     EUR/Month

LC FTE fraction of total FTE=  
total FTE LC/total FTE          Dmnl

LC replacing HC quit=  
HC quit-HC hire           Person/Month

LC quit=  
  Productive FTE LC*LC QUIT FRACTION          Person/Month

"HC CAPACITY USE ON HAND-OVER"=  
  0.5                                       Dmnl

LC TRAINING COST=  
  NN00                                     EUR/(Person*Month)

"LC micro- site optim.=  
  (1-HC FRACTION OF MICROSITES)*"MICRO-SITE OPTIMIZATION"          Person/Month

LC PRODUCTIVITY REDUCTION=  
  0.2 +0*0.2*PULSE(0, 48)                 Dmnl
LC ONGOING TRAVEL COST=
    NN0                     EUR/(Person*Month)

"LC HAND-OVER TRAVEL COST"=
    NN00                    EUR/(Person*Month)

cost per production=
    cost per month/production per month                     EUR/Person

total FTE=
    total FTE HC+total FTE LC                               Person

HC quit=
    Productive FTE HC*HC QUIT FRACTION                     Person/Month

HC hire=
    HC quit"REPLACEMENT IN HC VS. LC"                     Person/Month

"MICRO-SITE OPTIMIZATION"=
    0*(NN*PULSE(1, 1)+NN*PULSE(12, 1)
        +NN*PULSE(24, 1))                               Person/Month

HC FRACTION OF MICROSITES=
    0.5                     Dmnl

"HC micro-site optim."
    "MICRO-SITE OPTIMIZATION"
    *HC FRACTION OF MICROSITES                           Person/Month

STY month=
    1                     Month

HC person cost= INTEG (  
    +HC PERSON COST INCREASE RATE*HC person cost,  
   INI HC AVERAGE PERSON COSTS)                     EUR/(Month*Person)

INDEX production per month=  
    (production per month*STY month)/startindex production per month   Dmnl
INI HC AVERAGE PERSON COSTS =
NN0000/12 EUR/(Month*Person)

HC PERSON COST INCREASE RATE =
LN(1.025)/12 1/Month

INDEX cost per month =
(cost per month*STY month)/startindex cost per month Dmnl

startindex production per month = INTEG (production per month - production per month, production per month*STY month) Person

INDEX cost per production =
INDEX cost per month/INDEX production per month Dmnl

startindex cost per month = INTEG (cost per month - cost per month, cost per month*STY month) EUR

INI TOTAL FTE HC =
NN20 Person

Year production = INTEG (adding-reset production every year, 0) Person

make unit per month =
1 1/Month

reset production every year =
+IF THEN ELSE(Time=12, Year production/TIME STEP, 0)
+IF THEN ELSE(Time=24, Year production/TIME STEP, 0)
+IF THEN ELSE(Time=36, Year production/TIME STEP, 0)
+IF THEN ELSE(Time=48, Year production/TIME STEP, 0) Person/Month

Year cost = INTEG (+summing-reset cost every year, 0) EUR
reset cost every year =
+IF THEN ELSE(Time=12, Year cost/TIME STEP, 0)
+IF THEN ELSE(Time=24, Year cost/TIME STEP, 0)
+IF THEN ELSE(Time=36, Year cost/TIME STEP, 0)
+IF THEN ELSE(Time=48, Year cost/TIME STEP, 0)    EUR/Month

HC trained =
DELAY N(HC hire, HC TRAINING TIME,
New hired FTE HC/HC TRAINING TIME, 12)    Person/Month

LC ROOKIE PRODUCTIVITY =
0.5    Dmnl

HC TRAINING COS
NN00    EUR/(Person*Month)

LC TRAINING TIME =
2    Month

New hired FTE HC = INTEG (HC hire-HC trained,
HC TRAINING TIME/(HC TRAINING TIME+HC ROOKIE TIME)
*INI TOTAL FTE HC
/(1+(1/((HC TRAINING TIME+HC ROOKIE TIME)
*HC QUIT FRACTION))))    Person

HC ROOKIE PRODUCTIVITY =
0.5    Dmnl

HC TRAINING TIME =
3    Month

"REPLACEMENT IN HC VS. LC" =
0.4*(PULSE(0, 12)
+PULSE(12, 12)
+PULSE(24, 12))
+1*(PULSE(36, 12)
+PULSE(48, 12))    Dmnl
Appendix B

total FTE HC=
   Rookie FTE HC+Productive FTE HC+New hired FTE HC  
   Person

HC ROOKIE TIME=
   6  
   Month

Rookie FTE HC= INTG ( 
   HC trained-"HC job-trained",
   HC ROOKIE TIME/(HC TRAINING TIME+HC ROOKIE TIME)
   *INI TOTAL FTE HC
   /(1+(1/((HC TRAINING TIME+HC ROOKIE TIME)
   *HC QUIT FRACTION))))  
   Person

HC QUIT FRACTION= 
   0.0NN/12 
   1/Month

INI TOTAL FTE LC= 
   NN0  
   Person

FINAL TIME = 60  
   ~ The final time for the simulation.

INITIAL TIME = 0  
   ~ The initial time for the simulation.

SAVEPER = TIME STEP  
   ~ The frequency with which output is stored.

TIME STEP = 0.25  
   ~ The time step for the simulation.
Appendix C: Equations for Stock Initializations

The stocks in the model are initialized based on the condition for equilibrium, where the total number of hirings in both low cost locations and high cost locations equals the number of employees leaving.

For both aging chains, the three stocks to be initialized are: Productive FTE, New hire FTE, and Rookie FTE.

The model input parameters used to calculate the initial values are: INI total FTE, QUIT FRACTION, TRAINING TIME, and ROOKIE TIME.

Three equilibrium equations are:

(1): \[ \text{INI total FTE} = \text{Productive FTE} + \text{New hire FTE} + \text{Rookie FTE} \]

(2): \[ \text{New hire FTE} + \text{Rookie FTE} = \text{Productive FTE} \times \text{QUIT FRACTION} \times (\text{TRAINING TIME}+\text{ROOKIE TIME}) \]

(3): \[ \text{New Hire FTE} = \frac{(\text{TRAINING TIME}/(\text{TRAINING TIME}+\text{ROOKIE TIME}))}{\text{New hire FTE}+ \text{Rookie FTE}} \]

resulting in the following stock initializations (see workings on next page):

- Productive FTE (ini) = \[ \frac{\text{INI TOTAL FTE}}{(1+(\text{ROOKIE TIME}+\text{TRAINING TIME}) \times \text{QUIT FRACTION})} \]

- New hire FTE (ini) = \[ \frac{(\text{TRAINING TIME} / (\text{TRAINING TIME}+\text{TOTAL ROOKIE TIME}))}{(1+(1/((\text{TRAINING TIME}+\text{TOTAL ROOKIE TIME})*\text{QUIT FRACTION})}}) \]

- Rookie FTE (ini) = \[ \frac{(\text{ROOKIE TIME}/(\text{TRAINING TIME}+\text{ROOKIE TIME}))}{(1+(1/((\text{TRAINING TIME}+\text{ROOKIE TIME})*\text{QUIT FRACTION})}}) \]
Initializing of the stocks in equilibrium (both LC and HC):

The three equilibrium equations:

1. \[ \text{INI total FTE} = \text{Productive FTE} + \text{New hire FTE} + \text{Rookie FTE} \]
2. \[ \text{Productive FTE} \times \text{QUIT FRACTION} \times (\text{TRAINING TIME}+\text{ROOKIE TIME}) = \text{New hire FTE} + \text{Rookie FTE} \]
3. \[ \text{New Hire FTE} = (\text{TRAINING TIME}/(\text{TRAINING TIME}+\text{ROOKIE TIME})) \times (\text{New hire FTE} + \text{Rookie FTE}) \]

gives when New hire FTE + Rookie FTE from equation (2) is entered into equation (1):

\[ \Rightarrow \text{INI total FTE} = \text{Productive FTE} + \text{Productive FTE} \times \text{QUIT FRACTION} \times (\text{TRAINING TIME}+\text{ROOKIE TIME}) \]

\[ \Rightarrow \text{Productive FTE} = \text{INI total FTE} / (1+(\text{TRAINING TIME}+\text{ROOKIE TIME}) \times \text{QUIT FRACTION}) \]

and also, when the result of Productive FTE from equation (2) is entered to equation (1):

\[ \text{INI total FTE} = ((\text{New hire FTE} + \text{Rookie FTE}) / \text{QUIT FRACTION} \times (\text{TRAINING TIME}+\text{ROOKIE TIME})) + \text{New hire FTE} + \text{Rookie FTE} \]

\[ \Rightarrow \text{INI total FTE} = (\text{New hire FTE} + \text{Rookie FTE}) \times (1+(1/\text{QUIT FRACTION} \times (\text{TRAINING TIME}+\text{ROOKIE TIME})) ) \]

\[ \Rightarrow (\text{New hire FTE} + \text{Rookie FTE}) = \text{INI total FTE} / (1+(1/\text{QUIT FRACTION} \times (\text{TRAINING TIME}+\text{ROOKIE TIME})) ) \]

And the initial values of each of New hire FTE and Rookie FTE are then found by the equation (3):

\[ \text{New hire FTE} = \text{LC TRAINING TIME}/(\text{LC TRAINING TIME}+\text{LC ROOKIE TIME}) \times (\text{INI TOTAL FTE LC}/1+(1/((\text{LC TRAINING TIME}+\text{LC ROOKIE TIME}) \times \text{LC QUIT FRACTION}))) \]

(and furthermore is the stock of LC H-O-R Rookies initialized with 0)
Appendix D, Figure 1: The preliminary model in the case study
Appendix E: Model without ‘Rate-on-Rate’ Modeling

The next page (Appendix E, Figure 2) is an adjusted version of the model, where the out-flow rates from the stocks are modeled as simple fractions of the level-values. This way, rate-on-rate modeling is avoided, which is often recommended in the literature. Some of the stocks had to be split up in two parts, in order to use this approach. Figure 1 shows a simulation run with the same parameter setting as used in the simulation runs in Chapter C. It should be noted that the main trends – and thereby the main model insights – are the same as in the original model, also for year 1, even though the adjusted model results in the new hiring policy influencing the stock of experienced employees from nearly the very beginning.

Appendix E, Figure 1: Simulation run of adjusted model (avoiding rate-on-rate)
Appendix E, Figure 2: Model without rate-on-rate modeling
Appendix F: Facilitator Observations and Key Quotes From Interviews

The observations and interview quotes are structured according to the evaluation framework described in chapter C.III. When nothing is indicated, observations and interview quotes were made during the project, i.e. fourth quarter 2004.

<table>
<thead>
<tr>
<th>Personal reactions to the modeling process:</th>
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<tbody>
<tr>
<td>Very early in the modeling process, an engaged and vital discussion started, showing a positive attitude in the sessions. A few persons were resistant to the process, due to disagreement with the intervention objectives. It is an interesting point, however, that not even the core-group person disagreeing with the objectives of the process could “resist the fun of modeling” when he took part in modeling sessions, as he and the other core members were very mathematically skilled and interested individuals.</td>
</tr>
<tr>
<td>“A few participants did not agree with the business objectives, and did therefore never really buy in”</td>
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<tr>
<td>Gain of learning, and changes in goal structures and mental models:</td>
</tr>
<tr>
<td>In the development of the preliminary model, the very first results already took form as the project owners gained some interesting insights. Something first considered as a potential mistake in the model turned out to be an important insight, and it became clear that one decision, that had just been made, had a stronger negative impact in year 1 than anticipated, and it was therefore decided to modify the decision, and make the transition over a longer time-span.</td>
</tr>
<tr>
<td>Through the discussions and model simulations in the modeling workshops, the core project team gained</td>
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insights and exchanged experience relating to the location strategy. Also, the model was a framework for the setting of parameters to be used in the business case in each of the business areas.

Through investigations of effects of the changes in the different parameters of the model, the core team identified effective optimization opportunities, as well as sensitivity risks. Some of the most important insights gained were the understanding of the ‘reinforcing growth loop’ motivating the intervention, of how relatively few non-replacements in high-cost countries could compensate for the costs of building up the required volume of R&D employees in low-cost countries, as well as distinct benefits of reducing training and hand-over-time compared to reducing costs of training and traveling.

Often, simulations served as an “eye-opener”. In a few cases a parameter was perceived as “not possible to reduce”, but through simulations with increased value, a strong impact was seen, and the individuals then opened up for discussion on what it would take to optimize a certain parameter, e.g. reduce hand-over time.

The initial setting of each of the most important parameters could be discussed for hours in both workshops and other related meetings. For example, it was a widely accepted “fact” among many of the project participants, that employees in low-cost countries often stayed for only 1-2 years, because as soon as they attained experience in R&D, they could get a higher paying job in a high-cost country. Through the parameter stipulation, facts came on the table, documenting a very low employee turnover in the low-cost countries. (This could be viewed in the context of Ackoff’s morale: “There is nothing so deceptive as an apparent truth”).
In the modeling sessions, especially in the parameter stipulation, knowledge and experience exchange took place across the business units. Especially one business unit had already high-scale experience with build-up of resources in low-cost countries. Using this modeling approach served as a forum for the transfer of best practices.

“The preliminary model was important to get confirmation on the feasibility of the objectives, and the preliminary model also gave a better understanding of the dynamics of the problem”

“Parameter discussions were effective in challenging assumptions”

“Simulations were strong in showing the importance of the different parameters”

“The exchange of Best Practices was one of the objectives for starting a cross-business unit process in the first place”

Commitment to the outcome of the modeling sessions: Modeling participants often argued supporting the insights gained in the modeling, when presenting the results in other meetings – but there were also a few examples, when this was not the case, primarily in situations with divergence between insights and personal interests.

Changes in behavior: “In general the team members developed business cases in compliance with the modeling insights and results, with only one exception”
Group communication:
The discussion seemed to be both very structured and very open and frank. The result-oriented process, however, did not leave time to go into depth in all of the relevant discussions, but due to the structure, most of the time invested by the participants in discussions was used very effectively.

A couple of times, the modeling helped to take focus away from discussions, when simulations proved the low importance of a parameter. Therefore, there was little relevance of the continuous discussion about the exact stipulation of the value.

“The discussion improved radically compared to the rather unstructured communication we had in the project, before we decided to use system dynamics. The model directed the discussions back to the core of the problem”

Communication and consensus:
Opinions on parameters were often very different within the core project team, and the model proved to function as a structure for fact-finding and alignment of perceptions.

“The approach makes it difficult for people to play politics”

Consensus:
Opinions on the importance of different causal-relationships differed initially, but through the model-building process a more shared understanding of the problem and its dynamics was created.

The discussion of the parameters often initiated longer discussions on how the strategy could and should be

<table>
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<tr>
<th>Observation</th>
<th>Observation</th>
<th>Interview</th>
<th>Observation</th>
<th>Observation</th>
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<tbody>
<tr>
<td>Group communication:</td>
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<td>Communication and consensus:</td>
<td>Opinions on parameters were often very different within the core project team, and the model proved to function as a structure for fact-finding and alignment of perceptions.</td>
<td>Consensus:</td>
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executed, as the parameter setting reflected implementation decisions; e.g. the logistic and cost model of traveling, how to structure knowledge transfer, etc.

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<tr>
<th>Common language:</th>
<th>Observation</th>
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<tr>
<td>Within the core project team, there was a tendency to increased alignment, but this was difficult to transfer to non-core members in the relatively short meetings with these people. Parts of the language did spread to some extent, such as “one employee is one employee” regardless of the type of location. The factor for reduced productivity in low-cost countries only reflects a lower average experience-level. A stronger outcome on this dimension would have required a less result-oriented process, with more time to in-depth discussion.</td>
<td>Interview</td>
</tr>
<tr>
<td>“Even more of an effect – especially outside the core team – would have been better”</td>
<td></td>
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<tr>
<th>Transfer of insights:</th>
<th>Observation</th>
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<tr>
<td>The model clearly confirmed some viewpoints that the project team wanted to communicate to the board and the corporate controlling. Whereas these insights did not have much “newness” value, it was very valuable to have a model that distinctly and clearly “proved” the matter. These type of insight included the worse-before-better effect, implying that the division even receiving a relatively large number of additional head-counts in year 1, would have no additional productivity, but rather a slightly reduced productivity. Also, the model showed very clearly that even the relatively large growth in the fraction of low-cost employees compared to the total number of employees, does not result in a decreased cost per produced development hour, as the inflation has stronger influence than the benefits to be realized through a location strategy of the discussed scope.</td>
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</table>
Running a few simulations appeared to be very convincing in the discussions with non-core stakeholders.

“the model made the strategy very transparent, with clear definitions – and was better than words for communication”

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<tr>
<th>System changes:</th>
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<tr>
<td>The board accepted the business cases developed in the project, and the hirings for 2005 went approx. as planned. Also, the business case was implemented in the 3 years business plan, and the execution should follow the plans.</td>
</tr>
<tr>
<td>The business unit that disagreed most with the project objectives has actually been “overperforming” year-end 2005 with regards to hirings in low-cost locations.</td>
</tr>
<tr>
<td>“The business cases are approved by the board, and incorporated in the budgets and business plans”</td>
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<tr>
<th>Results:</th>
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<tr>
<td>1½ years after the approval of the detailed implementation plans, the FTE ratio between low-cost and high-cost locations has increased beyond the plan. This must also be seen in relation to the fact, that due to the success of the company, more hiring were needed and approved than originally planned.</td>
</tr>
<tr>
<td>“The modeling clearly helped in getting the managers committed to the strategy to use the current success to build up capacity in low-cost locations, seeking to avoid having to lay off employees in less fortunate periods.”</td>
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</table>
### Efficiency:
The project kept established deadlines. Some disturbance and discussion took place due to the fact, that the intervention also encompassed many elements not included in the modeling.

Especially in the beginning of the project, there was a tendency among core team members to think of the modeling as an additional task, increasing the workload in an already stressed period of time. But on the other hand, the model helped both to structure and to facilitate the discussions, which are likely to have reduced the overall time spent by the core team. To obtain this efficiency, however, a lot of efforts were made in workshop and meeting preparation by the facilitator and project owners were made.

Overall, it seemed very efficient to use the chosen software to make a shared model on a high abstraction level, with easy simulation options. Some improvement in the software, however, would be welcomed, as quite a lot of “behind the scenes” work was needed in order to create nice and effective output-graphs in separate views, avoiding waisting time and thereby creating irritation towards the modeling efforts.

Also, even relatively small changes in structures could be very time-consuming to implement in the chosen software (Vensim).

<table>
<thead>
<tr>
<th>Quote</th>
<th>Source</th>
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<tbody>
<tr>
<td>“It was a very structured and effective process”</td>
<td>Interview</td>
</tr>
<tr>
<td>“The project progressed even better than planned due to discipline and focus in the process”</td>
<td>Interview</td>
</tr>
<tr>
<td>“Maybe even too efficient: more difficult to act politically in the budget-negotiation” (said with a smile)</td>
<td>Interview</td>
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<tr>
<td>Quality in results:</td>
<td>Observation</td>
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<tr>
<td>For SD practitioners, the model seems very simple, but it should be recognized that the project team first tried to handle the problem using a normal Excel-model, which became a complicated “black box”, where it was difficult to see and understand how the different parameters influenced the model.</td>
<td>Observation</td>
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<tr>
<th>Further use of SD:</th>
<th>Observation (Q2 2006)</th>
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<tbody>
<tr>
<td>One of the project owners has been partly involved in a later project using system dynamics. This later modeling project was initiated in another part of the organization, and due to the positive experiences in the location strategy project, the project owner positively supported the idea in his new role as project sponsor.</td>
<td>Observation (Q2 2006)</td>
</tr>
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<tr>
<th>Intervention driven by business objectives and targets:</th>
<th>Observation</th>
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<tbody>
<tr>
<td>The intervention was initiated with clear objectives and targets (directions from the board). Only a modeling process supporting this type of intervention was considered by the project owners. No participants questioned this circumstance.</td>
<td>Observation</td>
</tr>
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</table>

| “Most of our strategic projects are initiated with very clear business objectives and targets” | Observation |

<table>
<thead>
<tr>
<th>Project framing:</th>
<th>Observation</th>
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<tr>
<td>The project owners had no intentions of starting a group model building process from clean sheets of paper with the risk of losing control. This might be a general trend in the corporate environment; that executives have a clear view of the direction they want to drive a given change, and that they will not take the risk that a model could show contradicting results, which in their view could be</td>
<td>Observation</td>
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</table>
due to hidden errors in the model or the problem being addressed or conceptualized erroneously. Trust in the modeling process was gained through the preliminary model.

Compared to exploratory modeling, the targeted participative modeling approach restricts the problem-solving process (with regards to “what to do,” not in “how to do”). It is difficult to say whether this had negative impacts on the participants’ ownership and trust in the model. The questionnaires do not explicitly include questions regarding this possible impact of a preliminary model, due to the problem of measurements influencing the system (in this case creating negative attitudes).

The preliminary model confirmed some intuitive expectations of the project owners, and showed to be an effective mean of communicating these cause-effect relationships, which was a cornerstone in continuing the modeling efforts.

“A few participants did not agree with the business objectives and for that reason also not with the process, but nevertheless the process forced them in the decided direction, and through the modeling they gained some of the insights motivating the intervention in the first place”

“We were open about the premises for the process, and participants should therefore not feel in the slightest way manipulated” (This was the answer to a question, if the use of a preliminary model and fixed business objectives could have caused the participants to feel somewhat manipulated)

“Initially I was a bit skeptical, but along the process I started to trust the model”
“We got where we wanted to”

“The modeling helped changing the focus from ‘seeing only problems’ to discussing sustainable and fair execution”

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<tr>
<th>Context comparative conditions:</th>
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<tbody>
<tr>
<td>The problem was more politically sensitive than truly messy. There were clearly defined objectives and targets.</td>
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<tr>
<td>The case company has a strong tradition for employee empowerment and is a relatively un-hierarchical organization.</td>
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<tr>
<td>Attitude to intervention: it was a top-down decision to initiate the intervention, initially against the “true wish” of many of the participants, although most of them could agree with the rationale behind the intervention.</td>
</tr>
<tr>
<td>There was a technical environment with young and highly educated people with a tradition of mathematical and “rational” problem solving. All participants were perceived as high-performers and have been with the company for years.</td>
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<tr>
<th>Mechanism comparative conditions:</th>
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<tbody>
<tr>
<td>A preliminary quantitative model was used to investigate whether a model was appropriate to illustrate the change objectives. The preliminary model showed what main learning to anticipate.</td>
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<tr>
<td>The modeling process was focused on developing a relatively simple model that could illustrate an idea of the overall behavior of the problem-system without including</td>
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too many details, partly because overview was considered more important than detailed correctness (avoiding black-box effect), partly due to the fact that the system dynamics Vensim model was complemented by a more detailed excel-model with the format needed in the budgeting and business planning. The result was a model that was relatively easy to explain in even 1-2 hour meetings.

The observer (and facilitator) primarily had a theoretical foundation for SD modeling, with only little SD modeling experience, but has more than 10 years of planned organizational intervention experience, including other types of modeling.

The observer (and facilitator) had personal relationships with company executives, which could be expected to influence both ‘positively’ with regards to access to information and dialogues with the decision-makers, and ‘negatively’ with regards to creating biases. Although being a highly subjective observation, the observer had the impression that most of the participants were rather indifferent to the existence of personal relationships, which might be due to the fact that most of the participants were high-placed managers themselves with a high degree of self-confidence.
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