Model documentation guidelines following Forrester and Senge, 1980; Sterman, 2000 p. 881 Table 21-2; Meyers 2015 p. 3635 and Morecroft, 2015 p. 441.

Results must be fully replicable.

Table 1 – Description of validation process gradually building confidence in the model.

Test category: Structural	
Purpose of Test	Tools and Procedures
1-Integration Error Test	In the first test suggested by Lohmann and Meyers, (2015) and Sterman, (2000) the results of our models should not be sensitive to the choice of time step or integration method; the wrong time step or integration method can introduce spurious dynamics into our model. The test for such "DT error" cutting the time step from 0.125 in half to 0.0625 and running the model again, shows no matter change, as in Fig. 1. We also duplicate the time step in double to 0.25 and running the model again, no matter change either. If the results change in ways that matter, the time step was too large, so we should continue until the results are no longer sensitive to the choice of time step. Likewise, we run the model with alternate integration methods from Euler to RK4auto as in Fig. 3, shows no matter change either.
2-Extreme Condition Test	Extreme condition tests ask whether models behave appropriately when the inputs take on extreme values such as zero or max. value. We carried out in two main ways: by direct inspection of the model equations and by simulation. We examine each decision rule (rate equation) in the model and ask whether the output of the rule is feasible and reasonable even when each input to the equation takes on its maximum and minimum values. Results are in Figures 4 and 5.
3-Boundary Adequacy	We used model boundary charts, causal diagrams, stock and flow maps as Figures 6, 7 and 8, and direct inspection of model equations as in Table 2 Data source were interviews, observation, archival materials, review of literature, direct inspection /participation in system process, etc. We modify model to include plausible additional structure in each supply network position repeating sensitive analysis.
4-Structure Examination/Assessment	We conduct partial model tests of the intended rationality of decision rules. We develop disaggregate sub-models (Figs. 6, 7 and 8) and compare to aggregate formulations. Disaggregate suspect structures, repeating sensitivity analysis. We tested physical law that stocks can't become negative, outcomes could approach zero. All variables have measure units.
5-Dimensional Adequacy and Consistency	We use real world units of measure got from case studies, besides we check each sub-model variables units, to understand the structure or decision process we are trying to model (Figs. 9, 10 and 11).
6-Parameter assessment	We make examination to evaluate model's parameters against evidence or knowledge about the real system. The test utilizes both empirical, from cases BOM and theoretical information according to Haas et al., (2015). Hence, the test is conceptual and numerical. The conceptual parameter examination test is about construct validity. Numerical from cases bill of materials based on knowledge of the real system constrains is about real-world validity (detailed in set of Appendix 1).
7-Mass-balance Check	We procedure accumulating all the inflows and outflows over time for each resource being modeled in each sub-model and then use the following balance or checksum equation: (Sum of all inflows-Sum of all outflows +initial values of stocks-current values of stocks) *dt= 0 (Dangerfield, 2014; Lohmann and Meyers, 2015). No sub-model has gain mass (Figs 12,13 and 14).

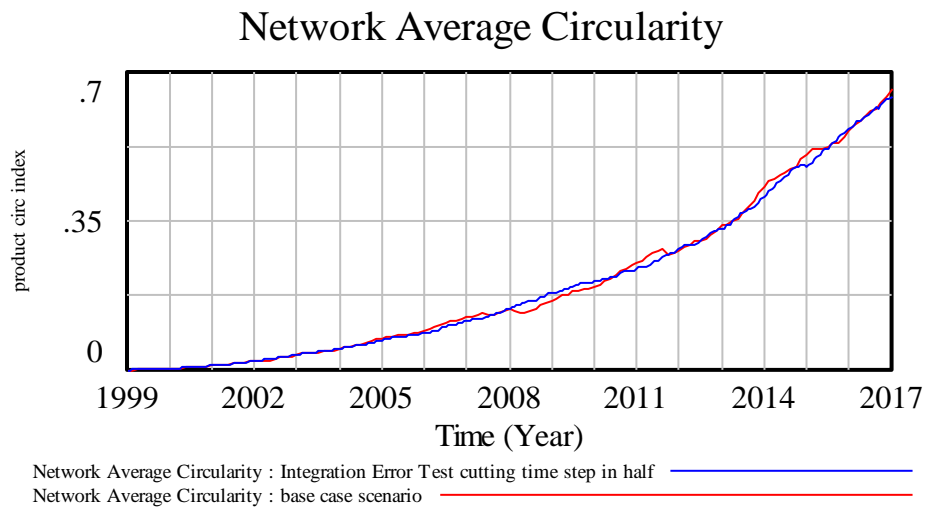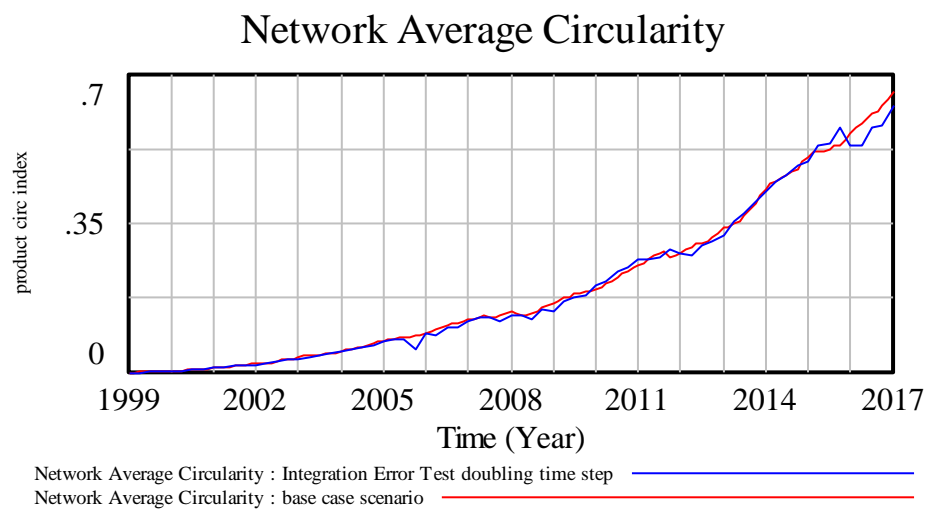| Test category: Behavioral	
8- Reproduction and symptom tests. Theil Inequality Statistic Test breakdown the mean square error in three components, bias, unequal variation and unequal covariation	The mean-square error (MSE) for Circularity is 0.02 and the root mean-square error (RMSE) is 0.14. The individual components of the inequality statistics are UM = 0.05 bias, US= 0.03 unequal variation, UC= 0.92 unequal covariation (Fig. 15). The decomposition shows that the major part of the error is due to the unequal covariation component, while the other two sources of error are small. This signifies that the point-by-point values of the simulated and the historical data do not perfect match, even though the model captures the dominant trend and the average values in the historical data. Such a situation indicates that the major part of the error is probably unsystematic and therefore that the model should not be rejected for failing to match the noise component of the data. The residuals of the historic and simulated time series show no significant trend. This strengthens the assessment that the model comprises of a structure that captures the fundamental dynamics of the issue under study. According to Sterman, (2000) many systems, including the supply chains and commodity markets, selectively amplify certain frequencies in the random shocks that constantly perturb them. Since no model can capture all the random variations in the environment.
9-Family Member and Multiple Modes Test	The family member test asks whether the model can generate the behavior of other instances in the same class (CESN) as the system the model was built to mimic. Our model of CESN implementation and growth can explain why some other circular networks, with different policies and parameters, experience growth, this test permits a repeat of the other tests of the model in the context of different special cases that fall within the general theory covered by the model. The general theory is embodied in the structure of the model. The mode is a pattern of observed behavior. The multiple mode test considers whether a model is able to generate more than one mode of observed behavior. We replicate our model to Case 1 parameters and policies as shown in Fig. 16.
Test category: Contextual	
10-Model Framing and Issue Identification	Model has orientative purpose and clear goal defined in problem articulation. Besides recurrently tested during model building.
11-Issue identification and Adequacy of Methodology Test	System Dynamics methodology is best-suited for dealing with the issue under study. Once the issue is characterized by dynamic complexity, feedback loop mechanisms, nonlinear interdependency of structural elements, and delays between causes and effects. Besides CESN management to foster CE system must be studied in a dynamic way understanding the process over time.
12-System Improvement	Finished model compared to real world reference mode was tested in base case scenario Fig 16.
13-System configuration	CESN management developed framework focused on recycling process in that a hybrid loop configuration adding several industries chains in a network was the best choice Fig. 17.

1- Integration Error Test

Network Average Circularity

Network Average Circularity : Integration Error Test cutting time step in half ————
Network Average Circularity : base case scenario ————

Fig.1 Cutting time step in half

Network Average Circularity

Network Average Circularity : Integration Error Test doubling time step ————
Network Average Circularity : base case scenario ————

Fig. 2 Doubling time step

Network Average Circularity

Network Average Circularity : Integration Error Test Euler-RK4Auto ————
Network Average Circularity : base case scenario ————

Fig. 3 Integration Error alternate integration method from Euler to RK4auto.

2- Extreme Condition Test

Network Average Circularity

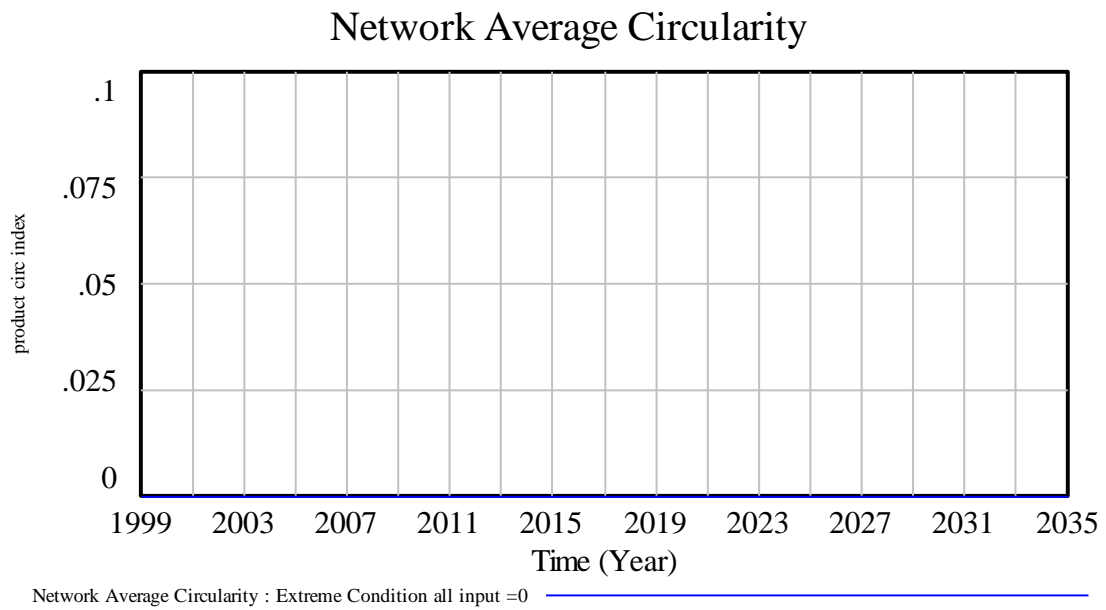Network Average Circularity : Extreme Condition all input =0

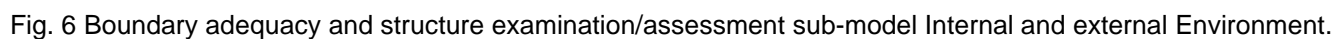Fig. 4 Extreme condition simulation all inputs =0.

Network Average Circularity

Network Average Circularity : extreme condition all inputs in max. value
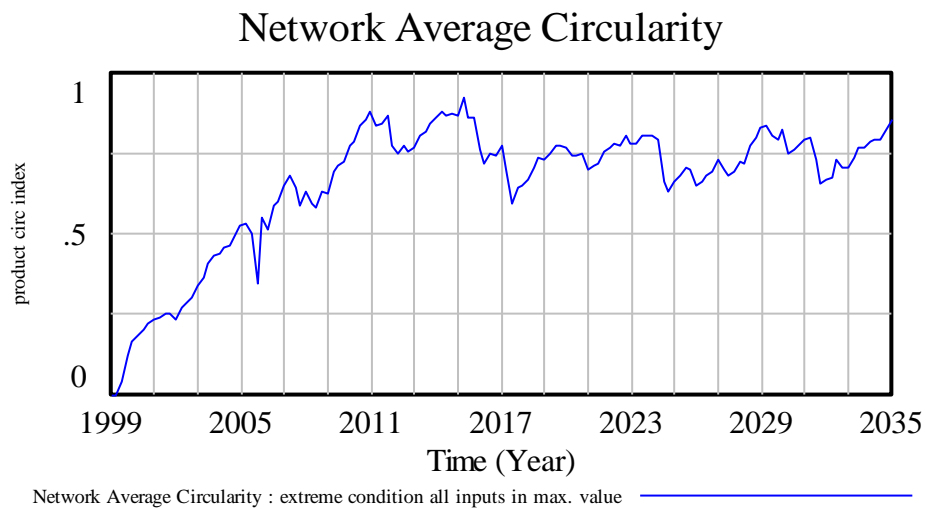
Fig. 5 Extreme condition simulation all inputs in max. value = 1.

3- Boundary Adequacy Test

4- Structure Examination/Assessment Test

Fig. 6 Boundary adequacy and structure examination/assessment sub-model Internal and external Environment.

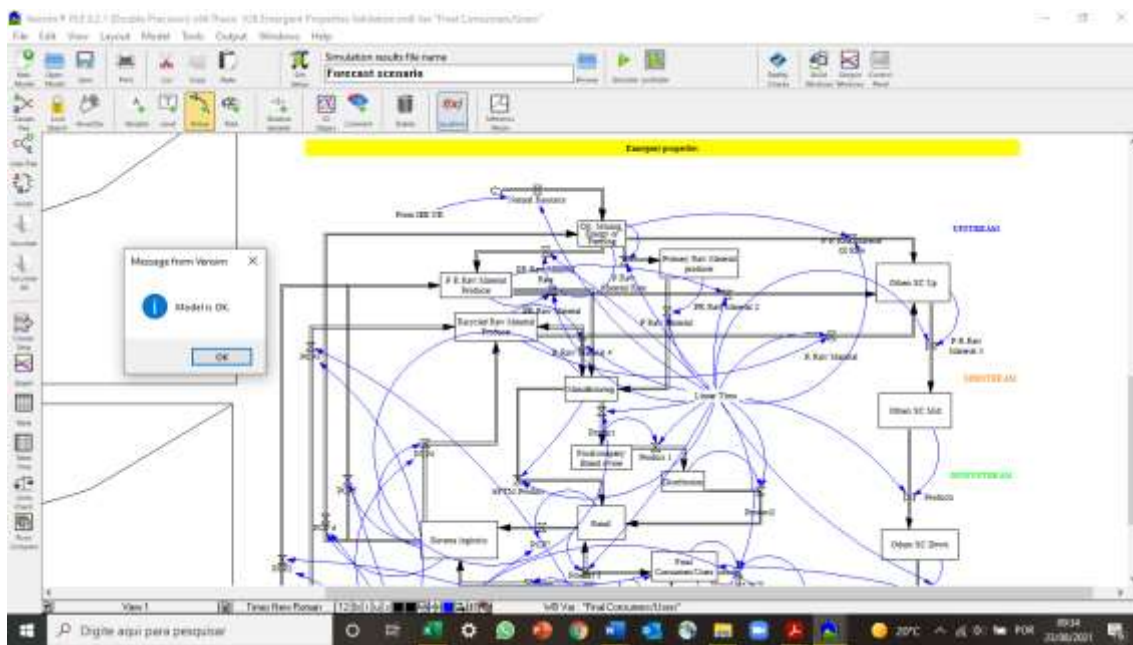Fig. 7 Boundary adequacy and structure examination/assessment sub-model Management Mechanisms.
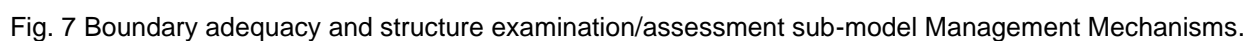
Fig. 8 Boundary adequacy and structure examination/assessment sub-model Management Mechanisms.

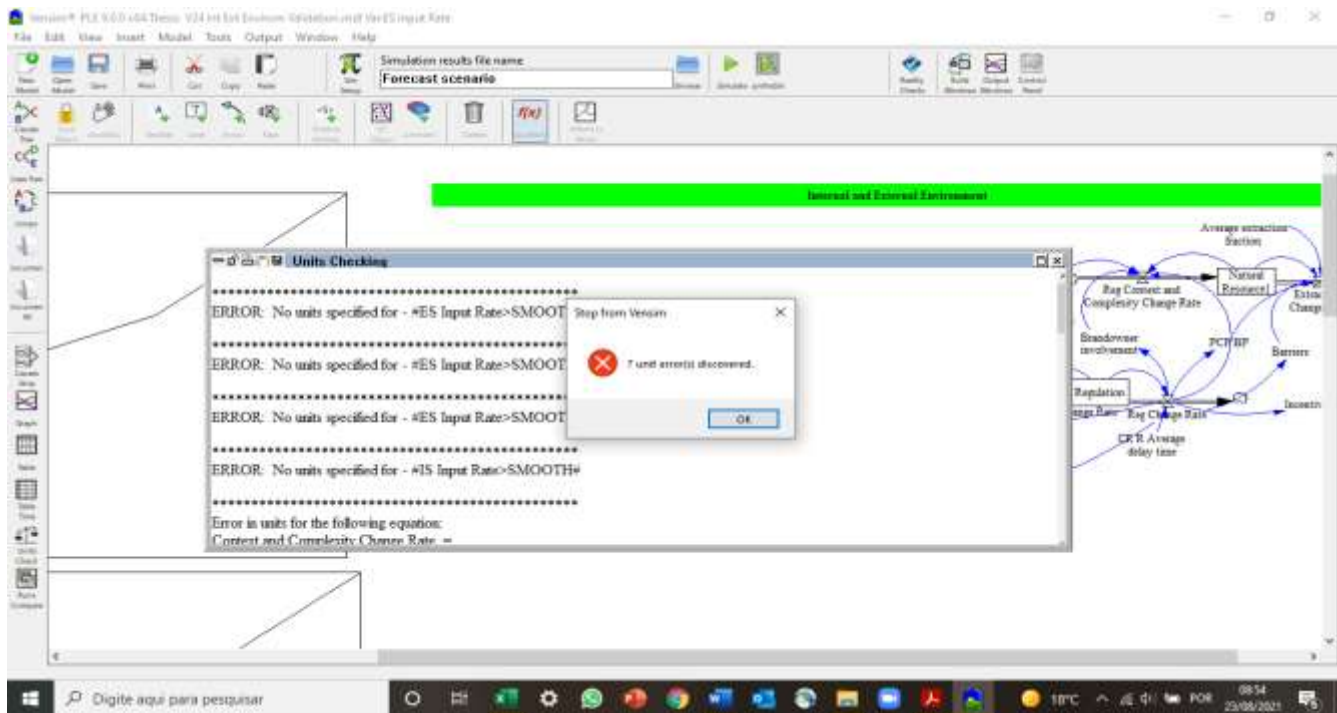## 5- Dimensional Adequacy and Consistency Test

Fig. 9-Dimensional adequacy and consistency sub-model Internal and external Environment.
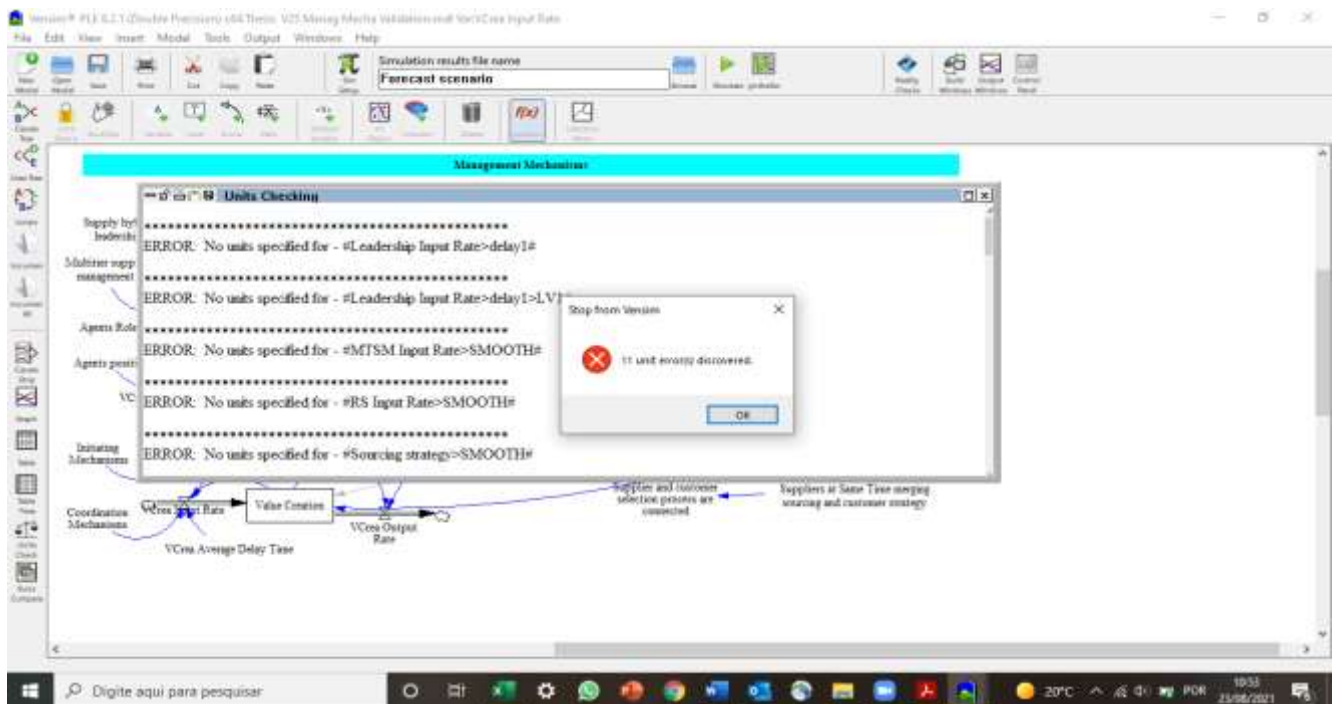

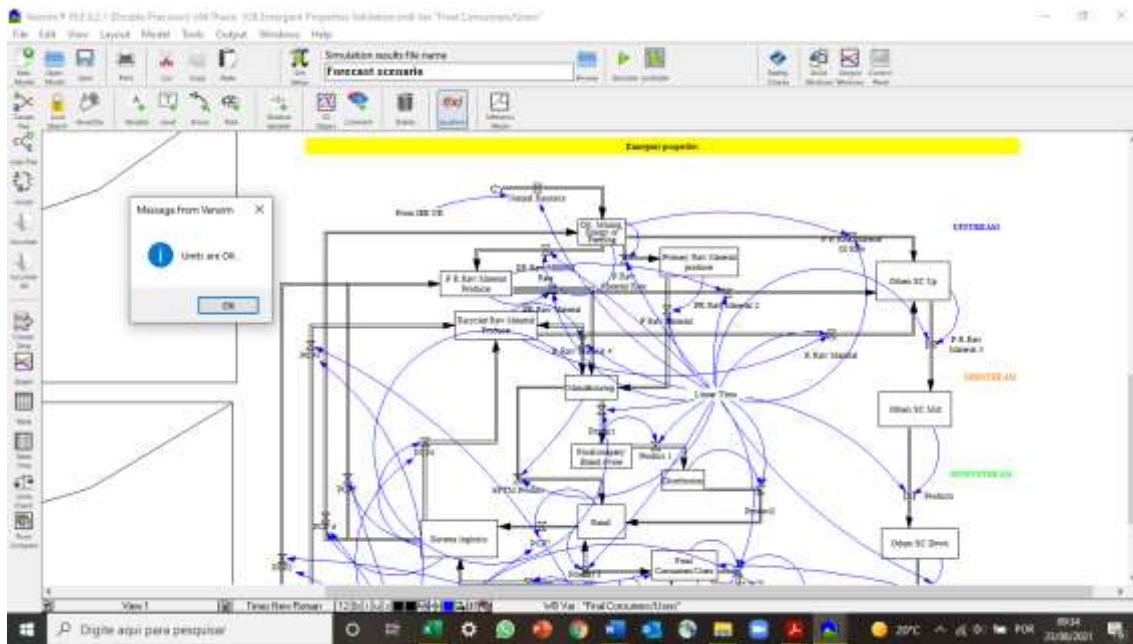Fig. 10Dimensional adequacy and consistency sub-model Management Mechanisms.

Fig. 11 Dimensional adequacy and consistency sub-model Emergent Circularity.
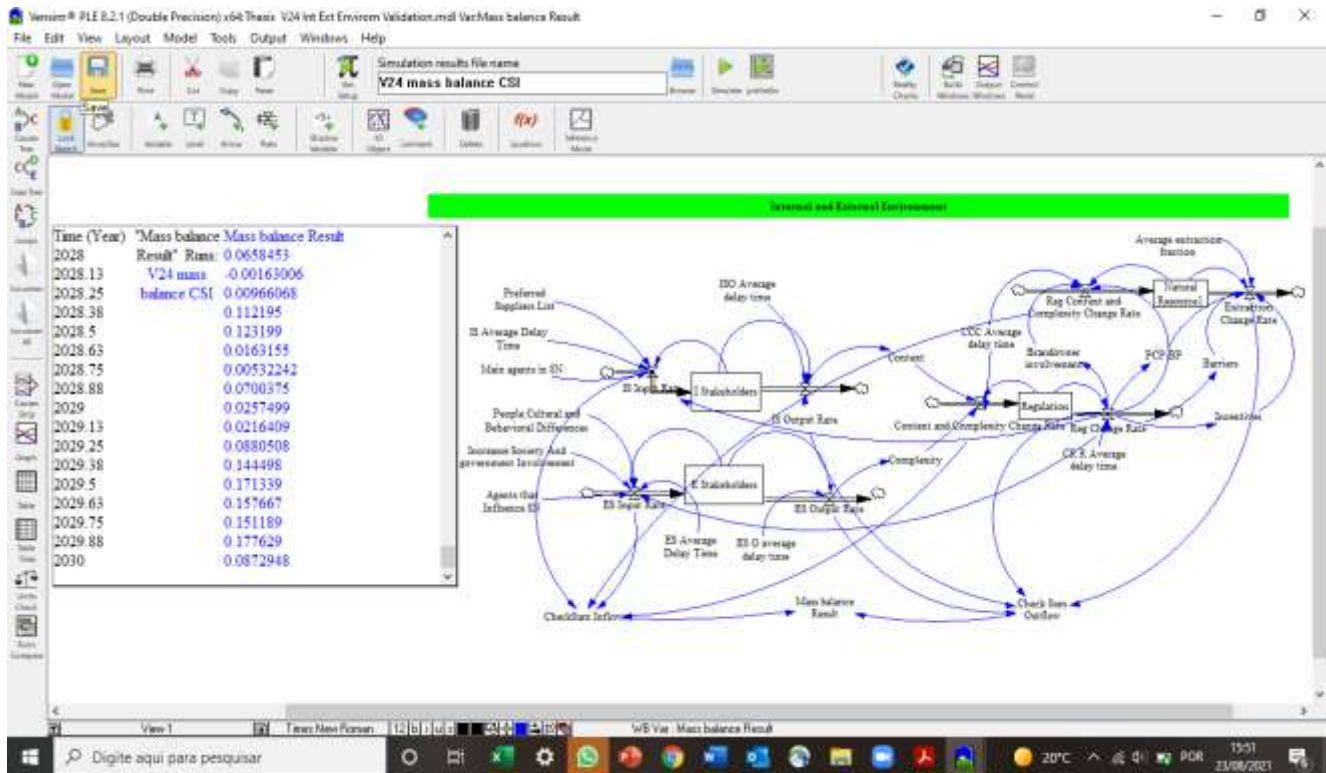
7- Mass Balance Test

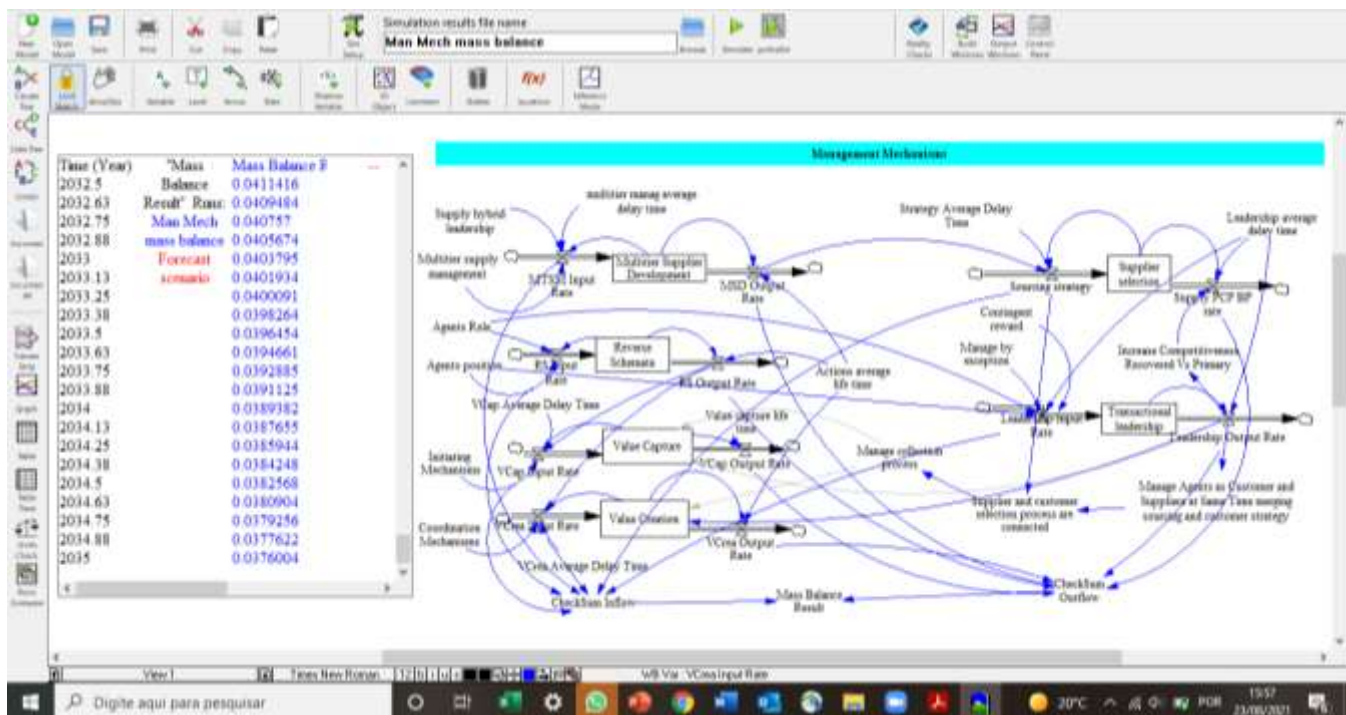Fig.12-Mass balance sub-model Internal and external Environment.

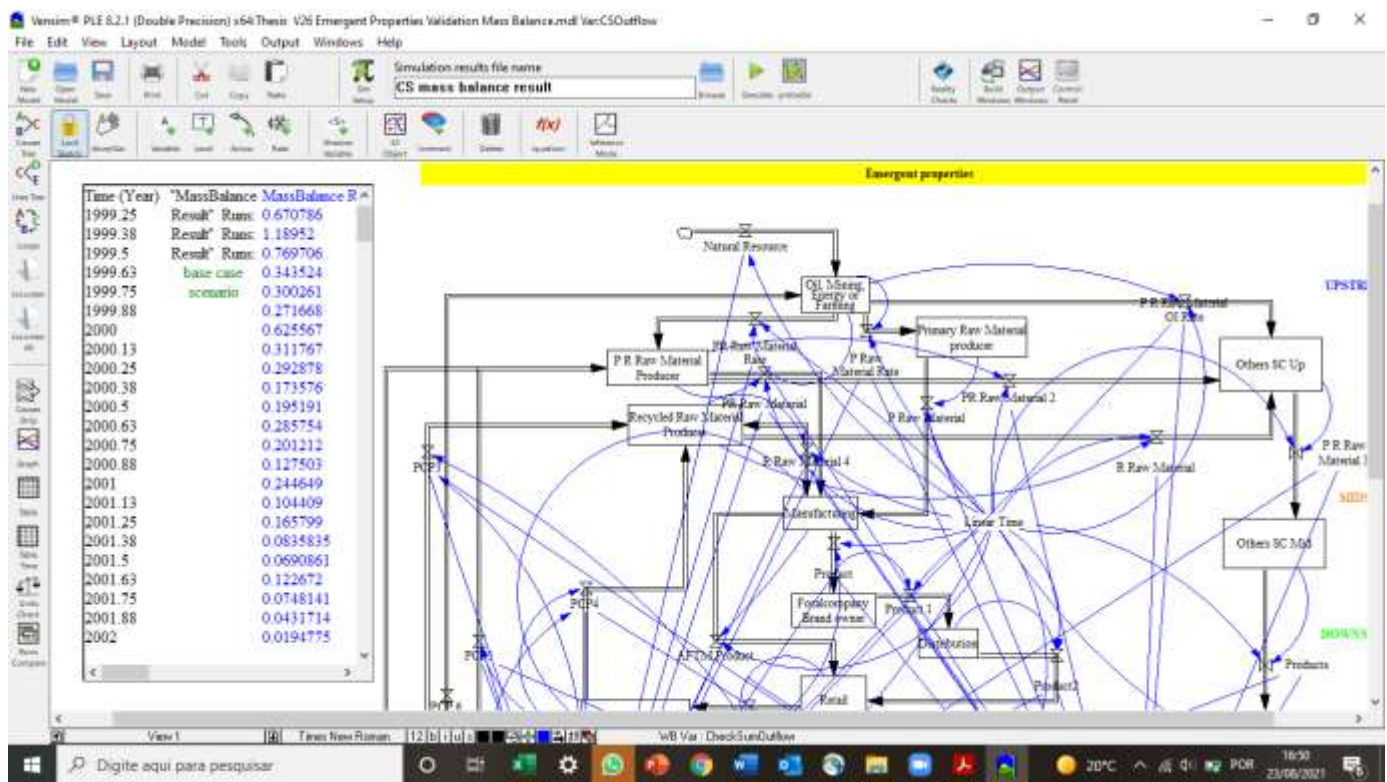Fig.13-Mass balance sub-model Management Mechanisms.

Fig.14-Mass balance sub-model Emergent Circularity.

8- Reproduction and symptom tests. Theil Inequality Statistic Test breakdown the mean square error in three components, bias, unequal variation and unequal covariation.

Mean Square error	MSE	0,02	RMSE
Bias	U^M	0,001061749	0,05
unequal variation	U^S	0,000544479	0,03
unequal covariation	U^c	0,01842285	0,91
		Total	1,0

Fig.15- Theil Inequality Statistic Test complete model for base case scenario Case 4.
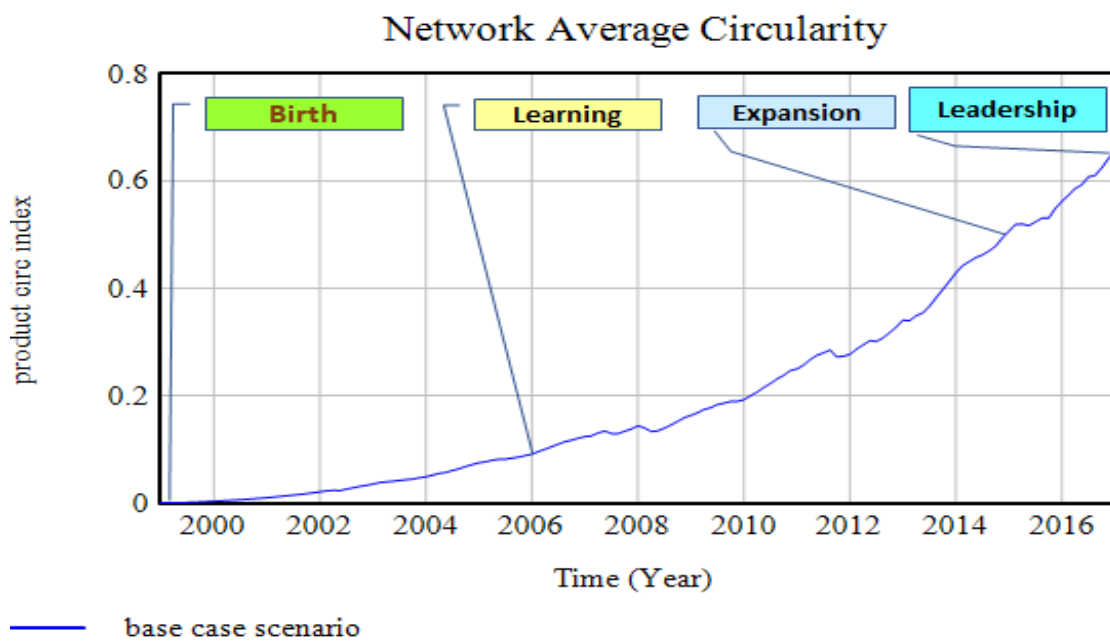
12- System Improvement Test.

Fig.16- System improvement test complete model for base case scenario Case 4.
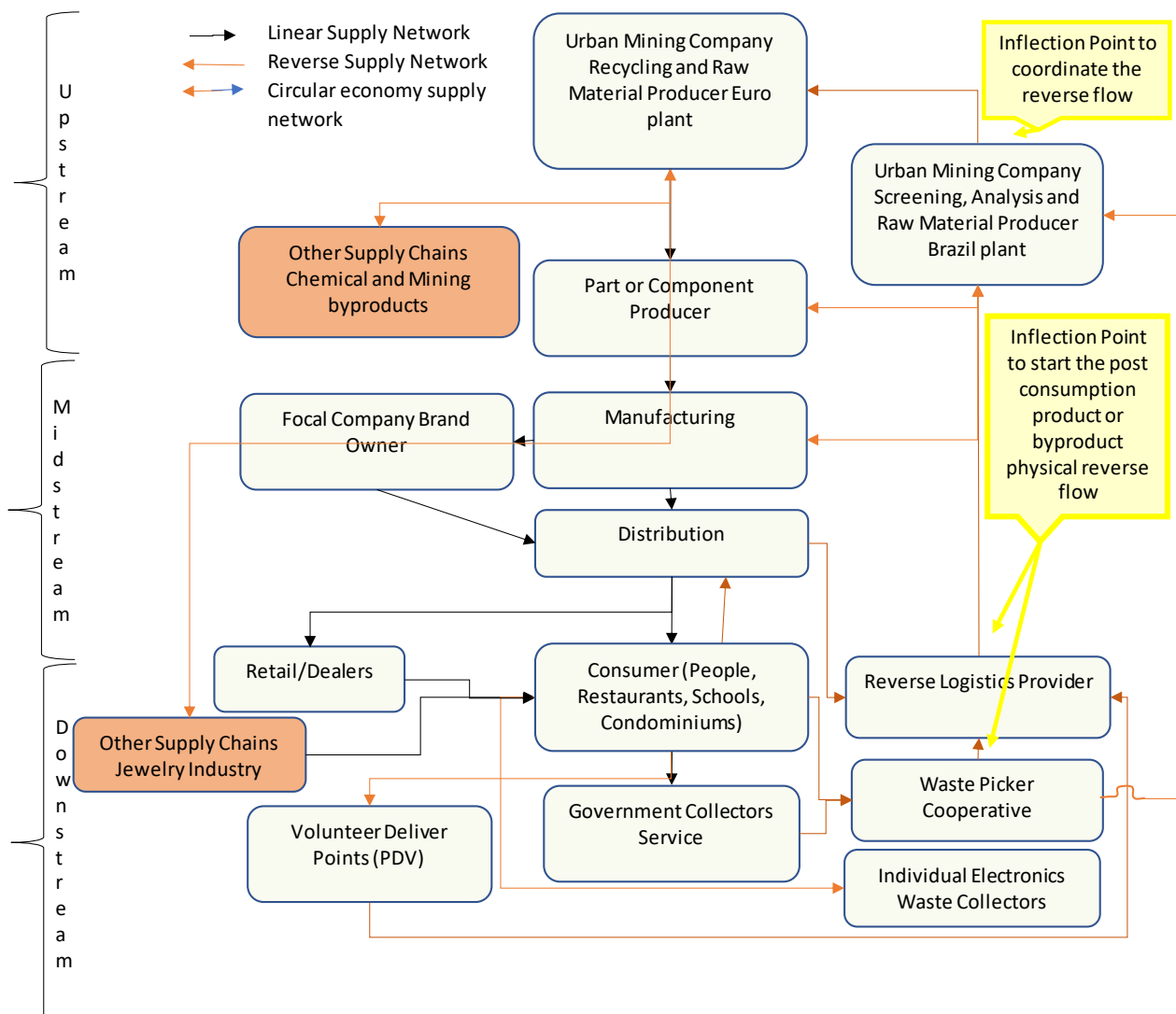
13- System Configuration Test.

Fig.17- System configuration test complete model for base case scenario Case 4.

Documentation of Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation

View the 118 variables sorted by type, module, group, module/group/name, view, Level Structure, or in a view summary.

Table 1 - Model Assessment Results

Model Information	Number
Total Number of Variables	118
Total Number of State Variables (Level+Smooth+Delay Variables)	32 (27.1%)
Total Number of Stocks (Stocks in Level+Smooth+Delay Variables) †	32 (27.1%)
Total Number of Macros	0
Variables with Source Information	0
Variables with Dimensionless Units	0
Variables without Predefined Min or Max Values	116 (98.3%)
Function Sensitivity Parameters	0
Data Lookup Tables	0
Time Unit	Year
Initial Time	1999
Final Time	2035
Reported Time Interval	time Step
Time Step	0.125
Model Is Fully Formulated	Yes
Modeler-Defined Groups	Yes
VPM File Available	Yes

Warnings	Number
Undocumented Equations	0

[Equations with Embedded Data](#) (0 and 1 constants ignored)	18 (15%)
[Equations With Unit Errors or Warnings](#)	Unavailable
[Variables Not in Any View](#)	0
[Incompletely Defined Subscripted Variables](#)	0
[Nonmonotonic Lookup Functions](#)	0
[Cascading (Chained) Lookup Functions](#)	0
[Non-Zero End Sloped Lookup Functions](#)	0
[Equations with "IF THEN ELSE" Functions](#)	4 (3.4%)
[Equations with "MIN" or "MAX" Functions](#)	17 (14.4%)
[Equations with "STEP", "PULSE", or Related Functions](#)	0

Potential Omissions	Number
[Unused Variables](#)	0
[Supplementary Variables](#)	0
[Supplementary Variables Being Used](#)	0
[Complex Variable Formulations (Richardson's Rule = 3 input variables)](#)	7
[Complex Stock Formulations](#)	0

Types:					
	L : Level (25 / **25**) *	**SM** : Smooth (5 / **5**) *	**DE** : Delay (2 / **2**) * †	**LI** : Level Initial (11)	**I** : Initial (0)
	C : Constant (25)	**F** : Flow (48)	**A** : Auxiliary (61)	**Sub**: Subscripts (0)	**D** : Data (0)
	G : Game (0)	**T** : Lookup (0 / **0**) ††			

* (state variables / **total stocks**)

† Total stocks do not include fixed delay variables.

†† (lookup variables / **lookup tables**).

Groups:	Control (4) Simulation Control Parameters	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (114) (Default)	
Modules:	**Default** (118)		

Table 2 – Detailed variables equations, types and group.

Module	Group	Type	*Variable Name* and Description
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#1 C	**Actions average life time** (Year) = 0.75 **Present in 1 view:** • [View 1](#) **Used by:** • [MSD Output Rate](#) • [RS Output Rate](#)

			• [VCrea Output Rate](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#2 F,A	**AFTM Product** (product circ index/Year) = [Manufacturing](#)/[Linear Time](#)/3 **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Context](#) • [Manufacturing](#) • [Retail](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#3 C	**Agents position** (product circ index) = 0.005 **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Leadership Input Rate](#) - x • [RS Input Rate](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#4 C	**Agents Role** (product circ index) = 0.005 **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Leadership Input Rate](#) - x • [RS Input Rate](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#5 A	**Agents that Influence SN** (product circ index) = RANDOM TRIANGULAR(0, 0.5 , 0.1 , 1 , 0.5, 0) **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [ES Input Rate](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#6 C	**Average extraction fraction** (1/Year) = 0.15 **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Extraction Change Rate](#) - x

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#7 A	**Barriers** (product circ index/Year) = IF THEN ELSE(Reg Change Rate>0, -Reg Change Rate , Reg Change Rate) **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Extraction Change Rate - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#8 A	**Brandowner involvement** (product circ index/Year) = IF THEN ELSE(Reg Change Rate>0, Reg Change Rate , 0) **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Reg Context and Complexity Change Rate - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#9 C	**CCC Average delay time** (Year) = 5 **Present in 1 view:** • View 1 **Used by:** • Context and Complexity Change Rate • Reg Context and Complexity Change Rate - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#10 A	**Complexity** (product circ index/Year) = ES Output Rate **Present in 1 view:** • View 1 **Used by:** • Context and Complexity Change Rate
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#11 A	**Context** (product circ index/Year) = IS Output Rate+AFTM Product+P R Raw Material OI Rate+Product 1+Product 3 **Present in 1 view:** • View 1 **Used by:** • Context and Complexity Change Rate
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#12 F,A	**Context and Complexity Change Rate** (product circ index/Year) = MIN (0.92, (Complexity+Context+Regulation)/CCC Average delay time) **Present in 1 view:** • View 1

			Used by: • [Regulation](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#13 C	**Contingent reward** (product circ index/Year) = 0.01 **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Leadership Input Rate](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#14 C	**Coordination Mechanisms** (product circ index) = 0.28 **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [VCrea Input Rate](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#15 C	**CR R Average delay time** (Year) = 5 **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Reg Change Rate](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#16 L	**Distribution** (product circ index) = $\int$([Product 1](#)-[Product2](#)) *dt* + [0] **Present in 1 view:** • [View 1](#) **Used by:** • [Product2](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#17 L	**E Stakeholders** (product circ index) = $\int$[ES Input Rate](#)-[ES Output Rate](#) *dt* + [0] **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [ES Input Rate](#) • [ES Output Rate](#) - x

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#18 C	**ES Average Delay Time** (Year) = 2.75 **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • ES Input Rate
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#19 DE,F	**ES Input Rate** (product circ index/Year) = DELAY1(((Agents that Influence SN*Reg Change Rate+Increasse Society And government Involvement+People Cultural and Behavioral Differences)-E Stakeholders), ES Average Delay Time) **Present in 1 view:** • View 1 **Used by:** • E Stakeholders - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#20 C	**ES O average delay time** (Year) = 1 **Present in 1 view:** • View 1 **Used by:** • ES Output Rate - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#21 F,A	**ES Output Rate** (product circ index/Year) = E Stakeholders/ES O average delay time **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Complexity • E Stakeholders - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#22 F,A	**Extraction Change Rate** (product circ index/Year) = Average extraction fraction*(Incentives-Barriers+PCP BP)*Natural Resource1 **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • From IEE NR - x • Natural Resource1 - x

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#23 L	**"Final Consumers/Users"** (product circ index)
			= ∫([Product 3](#)+[PCP 8](#)+[Product 4](#))-([Waste and PCP](#)+[PCP1](#)+[PCP 8](#)) *dt* + [0]
			Description: *x*
			Present in 1 view:
			
			    • [View 1](#)
			
			Used by:
			
			    • [PCP 8](#)
			    • [Waste and PCP](#)

Default	Control	#24 C	**FINAL TIME** (Year) = 2035 **Description:** *The final time for the simulation.* **Not Present In Any View**

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#25 L	**Focalcompany Brand owner** (product circ index)
			= ∫[Product](#)-[Product 1](#) *dt* + [[Leadership Output Rate](#)*[Supply PCP BP rate](#)*[MSD Output Rate](#)*[VCrea Output Rate](#)]
			Description: *x*
			Present in 1 view:
			
			    • [View 1](#)
			
			Used by:
			
			    • [Product 1](#) - x

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#26 A	**From IEE NR** (product circ index/Year)
			= [Extraction Change Rate](#)
			Description: *x*
			Present in 1 view:
			
			    • [View 1](#)
			
			Used by:
			
			    • [Natural Resource](#) - x

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#27 L	**GCS** (product circ index)
			= ∫[Waste and PCP](#)-[Landfill](#)-[PCP](#) *dt* + [0]
			Description: *x*
			Present in 1 view:
			
			    • [View 1](#)
			
			Used by:
			
			    • [Landfill](#) - x
			    • [PCP](#)

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#28 L	**I Stakeholders** (product circ index)
			= ∫[IS Input Rate](#)-[IS Output Rate](#) *dt* + [0]
			Description: *x*
			Present in 1 view:
			
			    • [View 1](#)
			
			Used by:
			
			    • [IS Input Rate](#) - x

			•	IS Output Rate
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#29 A	**Incentives** (product circ index/Year) = IF THEN ELSE(Reg Change Rate>0, Reg Change Rate , -Reg Change Rate) **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Extraction Change Rate - x	
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#30 A	**Increase Competitiveness Recovered Vs Primary** (product circ index/Year) = Leadership Output Rate **Present in 1 view:** • View 1 **Used by:** • Supply PCP BP rate - x	
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#31 A	**Increasse Society And government Involvement** (product circ index) = RANDOM TRIANGULAR(0, 0.5 , 0.1 , 1 , 0.5, 0) **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • ES Input Rate	
Default	Control	#32 C	**INITIAL TIME** (Year) = 1999 **Description:** *The initial time for the simulation.* **Not Present In Any View** **Used by:** • Time - Internally defined simulation time.	
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#33 C	**Initiating Mechanisms** (product circ index) = 0.28 **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • VCap Input Rate	
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#34 C	**IS Average Delay Time** (Year) = 0.6 **Description:** *x* **Present in 1 view:**	

			• [View 1](#) **Used by:** • [IS Input Rate](#) - x • [RS Input Rate](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#35 SM,F	**IS Input Rate** (product circ index/Year) = SMOOTH([I Stakeholders](#)*[Reg Change Rate](#)-[Main agents in SN](#)+[Preferred Suppliers List](#), [IS Average Delay Time](#)) **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [I Stakeholders](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#36 F,A	**IS Output Rate** (product circ index/Year) = [I Stakeholders](#)/[ISO Average delay time](#) **Present in 1 view:** • [View 1](#) **Used by:** • [Context](#) • [I Stakeholders](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#37 C	**ISO Average delay time** (Year) = 1 **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [IS Output Rate](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#38 F,A	**Landfill** (product circ index/Year) = [GCS](#)/[Non Linear Time](#) **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [GCS](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#39 C	**Leadership average delay time** (Year) = 1 **Description:** *x* **Present in 1 view:** • [View 1](#)

			Used by: • [Leadership Input Rate](#) - x • [Leadership Output Rate](#) - x • [Supply PCP BP rate](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#40 DE,F	**Leadership Input Rate** (product circ index/Year) = DELAY1([Contingent reward](#)+[Manage by exception](#)+[Agents Role](#)+[Agents position](#), [Leadership average delay time](#)) **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Transactional leadership](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#41 LI,F,A	**Leadership Output Rate** (product circ index/Year) = MIN (0.92, [Transactional leadership](#)/[Leadership average delay time](#)) **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Focalcompany Brand owner](#) - x • [Increase Competitiveness Recovered Vs Primary](#) • [Manage Agents as Customer and Suppliers at Same Time merging sourcing and customer strategy](#) - x • [Manufacturing](#) • ["Oil, Mining, Energy or Farming"](#) - x • [Transactional leadership](#) - x • [Value Capture](#) - x • [Value Creation](#) • [WPC](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#42 A	**Linear Time** (Year) = RANDOM TRIANGULAR(0.25, 0.75 , 0.1 , 0.75 , 0.75 , 0) **Present in 1 view:** • [View 1](#) **Used by:** • [AFTM Product](#) - x • [Natural Resource](#) - x • [P R Raw Material 3](#) • [P R Raw Material OI Rate](#) - x • [P Raw Material](#) - x • [P Raw Material Rate](#) • [PR Raw Material](#) • [PR Raw Material 2](#) • [PR Raw Material Rate](#) - x • [Product](#) • [Product 1](#) - x • [Product 3](#) • [Product 4](#) • [Product2](#) • [Products](#)

			• [R Raw Material](#) • [R Raw Material 4](#) - x • [Waste and PCP](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#43 A	**Main agents in SN** (product circ index) = RANDOM TRIANGULAR(0, 0.5 , 0.1 , 1 , 0.5, 0) **Present in 1 view:** • [View 1](#) **Used by:** • [IS Input Rate](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#44 A	**Manage Agents as Customer and Suppliers at Same Time merging sourcing and customer strategy** (product circ index/Year) = [Leadership Output Rate](#) **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Supplier and customer selection process are connected](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#45 C	**Manage by exception** (product circ index/Year) = 0.01 **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Leadership Input Rate](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#46 LI,A	**Manage collection process** (product circ index/Year) = [Supplier and customer selection process are connected](#) **Present in 1 view:** • [View 1](#) **Used by:** • [Value Capture](#) - x • [Value Creation](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#47 L	**Manufacturing** (product circ index) = ∫[P Raw Material](#)+[PR Raw Material](#)+[R Raw Material 4](#)-[AFTM Product](#)-Product *dt* + [[Leadership Output Rate](#)*[Supply PCP BP rate](#)*[MSD Output Rate](#)*[VCrea Output Rate](#)] **Present in 1 view:** • [View 1](#) **Used by:** • [AFTM Product](#) - x • [Network Average Circularity](#)

			• [Product](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#48 LI,F,A	**MSD Output Rate** (product circ index/Year) = [Multitier Supplier Development](#)/[Actions average life time](#) **Present in 1 view:** • [View 1](#) **Used by:** • [Focalcompany Brand owner](#) - x • [Manufacturing](#) • [Multitier Supplier Development](#) - x • ["Oil, Mining, Energy or Farming"](#) - x • [Recycled Raw Material Producer](#) - x • [Sourcing strategy](#) - x • [WPC](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#49 SM,F	**MTSM Input Rate** (product circ index/Year) = SMOOTH([Multitier Supplier Development](#)*[Multitier supply management](#)+[Supply hybrid leadership](#), [multitier manag average delay time](#)) **Present in 1 view:** • [View 1](#) **Used by:** • [Multitier Supplier Development](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#50 C	**multitier manag average delay time** (Year) = 1 **Present in 1 view:** • [View 1](#) **Used by:** • [MTSM Input Rate](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#51 L	**Multitier Supplier Development** (product circ index) = ∫[MTSM Input Rate](#)-[MSD Output Rate](#) *dt* + [0] **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [MSD Output Rate](#) • [MTSM Input Rate](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#52 C	**Multitier supply management** (product circ index) = 0.28 **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:**

				• MTSM Input Rate
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#53 F,A		**Natural Resource** (product circ index/Year) = From IEE NR/Linear Time **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • "Oil, Mining, Energy or Farming" - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#54 L		**Natural Resource1** (product circ index) = ∫Reg Context and Complexity Change Rate+Supply PCP BP rate-Extraction Change Rate *dt* + [0] **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Extraction Change Rate - x • Reg Context and Complexity Change Rate - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#55 A		**Network Average Circularity** (product circ index) = (Manufacturing+"Oil, Mining, Energy or Farming"+Reverse logistics)/3 **Present in 1 view:** • View 1
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#56 A		**Non Linear Time** (Year) = RANDOM TRIANGULAR(0.6, 5 , 0.6 , 5 , 2 , 0) **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Landfill - x • PCP • PCP 6 • PCP 8 • PCP1 • PCP2 • PCP3 - x • PCP4 • PCP5 • PCP7
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#57 L		**"Oil, Mining, Energy or Farming"** (product circ index) = ∫Natural Resource+PCP 6-P R Raw Material OI Rate-P Raw Material Rate-PR Raw Material Rate *dt* + [VCrea Output Rate*MSD Output Rate*Leadership Output Rate*Supply PCP BP rate] **Description:** *x* **Present in 1 view:**

			• View 1 **Used by:** • Network Average Circularity • P R Raw Material OI Rate - x • P Raw Material Rate • PR Raw Material Rate - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#58 L	**Others SC Down** (product circ index) = ∫Products-Product 4 *dt* + [0] **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Product 4
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#59 L	**Others SC Mid** (product circ index) = ∫P R Raw Material 3-Products *dt* + [0] **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Products
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#60 L	**Others SC Up** (product circ index) = ∫P R Raw Material OI Rate+PR Raw Material 2+R Raw Material-P R Raw Material 3 *dt* + [0] **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • P R Raw Material 3
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#61 F,A	**P R Raw Material 3** (product circ index/Year) = Others SC Up/Linear Time **Present in 1 view:** • View 1 **Used by:** • Others SC Mid - x • Others SC Up - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#62 F,A	**P R Raw Material OI Rate** (product circ index/Year) = (["Oil, Mining, Energy or Farming"](Oil, Mining, Energy or Farming)/3)/Linear Time **Description:** *x* **Present in 1 view:**

			• [View 1](#) **Used by:** • [Context](#) • ["Oil, Mining, Energy or Farming"](#) - x • [Others SC Up](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#63 L	**P R Raw Material Producer** (product circ index) = ∫[PR Raw Material Rate](#)+[PCP2](#)+[PCP5](#)-[PR Raw Material](#)-[PR Raw Material 2](#) *dt* + [[Supply PCP BP rate](#)] **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [PR Raw Material](#) • [PR Raw Material 2](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#64 F,A	**P Raw Material** (product circ index/Year) = ([Primary Raw Material producer](#)/3)/[Linear Time](#) **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Manufacturing](#) • [Primary Raw Material producer](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#65 F,A	**P Raw Material Rate** (product circ index/Year) = ["Oil, Mining, Energy or Farming"](#)/[Linear Time](#) **Present in 1 view:** • [View 1](#) **Used by:** • ["Oil, Mining, Energy or Farming"](#) - x • [Primary Raw Material producer](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#66 F,A	**PCP** (product circ index/Year) = MIN(0.92,[GCS](#)/[Non Linear Time](#)) **Present in 1 view:** • [View 1](#) **Used by:** • [GCS](#) - x • [WPC](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#67 LI,F,A	**PCP 6** (product circ index/Year) = [Reverse logistics](#)/[Non Linear Time](#) **Present in 1 view:**

				• [View 1](#) **Used by:** • ["Oil, Mining, Energy or Farming"](#) - x • [Reverse logistics](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#68 F,A		**PCP 8** (product circ index/Year) = MIN(0.92, ["Final Consumers/Users"](#)/[Non Linear Time](#)) **Present in 1 view:** • [View 1](#) **Used by:** • ["Final Consumers/Users"](#) - x • [WPC](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#69 A		**PCP BP** (product circ index/Year) = IF THEN ELSE([Reg Change Rate](#)>0, [Reg Change Rate](#) , +[Reg Change Rate](#)) **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Extraction Change Rate](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#70 LI,F,A		**PCP1** (product circ index/Year) = MIN(0.9,[WPC](#)/[Non Linear Time](#)) **Present in 1 view:** • [View 1](#) **Used by:** • ["Final Consumers/Users"](#) - x • [Reverse logistics](#) • [WPC](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#71 F,A		**PCP2** (product circ index/Year) = MIN(0.95,[WPC](#)/2/3/[Non Linear Time](#)) **Present in 1 view:** • [View 1](#) **Used by:** • [P R Raw Material Producer](#) - x • [WPC](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#72 F,A		**PCP3** (product circ index/Year) = MIN(0.9,DELAY1([WPC](#), [Non Linear Time](#))/[Non Linear Time](#)) **Description:** *x* **Present in 1 view:**

			• [View 1](#) **Used by:** • [Recycled Raw Material Producer](#) - x • [WPC](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#73 LI,F,A	**PCP4** (product circ index/Year) = MIN(0.9,[Reverse logistics](#)/3/[Non Linear Time](#)) **Present in 1 view:** • [View 1](#) **Used by:** • [Recycled Raw Material Producer](#) - x • [Reverse logistics](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#74 LI,F,A	**PCP5** (product circ index/Year) = MIN(0.95,(DELAY1([Reverse logistics](#)/3, [Non Linear Time](#)))/3/[Non Linear Time](#)) **Present in 1 view:** • [View 1](#) **Used by:** • [P R Raw Material Producer](#) - x • [Reverse logistics](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#75 LI,F,A	**PCP7** (product circ index/Year) = MIN(0.9,[Retail](#)/[Non Linear Time](#)) **Present in 1 view:** • [View 1](#) **Used by:** • [Retail](#) - x • [Reverse logistics](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#76 A	**People Cultural and Behavioral Differences** (product circ index) = RANDOM TRIANGULAR(0, 0.5 , 0.1 , 1 , 0.5, 0) **Present in 1 view:** • [View 1](#) **Used by:** • [ES Input Rate](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#77 F,A	**PR Raw Material** (product circ index/Year) = ([P R Raw Material Producer](#)/3)/[Linear Time](#) **Present in 1 view:** • [View 1](#) **Used by:**

			• [Manufacturing](#) • [P R Raw Material Producer](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#78 F,A	**PR Raw Material 2** (product circ index/Year) = ([P R Raw Material Producer](#)/3)/[Linear Time](#) **Present in 1 view:** • [View 1](#) **Used by:** • [Others SC Up](#) - x • [P R Raw Material Producer](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#79 F,A	**PR Raw Material Rate** (product circ index/Year) = (["Oil, Mining, Energy or Farming"](#)/[Linear Time](#))/3 **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • ["Oil, Mining, Energy or Farming"](#) - x • [P R Raw Material Producer](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#80 A	**Preferred Suppliers List** (product circ index) = RANDOM TRIANGULAR(0, 1 ,0 , 1 , 1 , 0)*[Supplier selection](#) **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [IS Input Rate](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#81 L	**Primary Raw Material producer** (product circ index) = ∫[P Raw Material Rate](#)+[Supply PCP BP rate](#)-[P Raw Material](#) *dt* + [[Supply PCP BP rate](#)] **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [P Raw Material](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#82 F,A	**Product** (product circ index/Year) = MIN(0.95,[Manufacturing](#)/[Linear Time](#)) **Present in 1 view:** • [View 1](#) **Used by:** • [Focalcompany Brand owner](#) - x

			• [Manufacturing](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#83 F,A	**Product 1** (product circ index/Year) = [Focalcompany Brand owner](#)/[Linear Time](#) **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Context](#) • [Distribution](#) • [Focalcompany Brand owner](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#84 F,A	**Product 3** (product circ index/Year) = [Retail](#)/[Linear Time](#)/3 **Present in 1 view:** • [View 1](#) **Used by:** • [Context](#) • ["Final Consumers/Users"](#) - x • [Retail](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#85 F,A	**Product 4** (product circ index/Year) = [Others SC Down](#)/[Linear Time](#) **Present in 1 view:** • [View 1](#) **Used by:** • ["Final Consumers/Users"](#) - x • [Others SC Down](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#86 F,A	**Product2** (product circ index/Year) = MIN (0.92, [Distribution](#)/3/[Linear Time](#)) **Present in 1 view:** • [View 1](#) **Used by:** • [Distribution](#) • [Retail](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#87 F,A	**Products** (product circ index/Year) = [Others SC Mid](#)/[Linear Time](#) **Present in 1 view:** • [View 1](#) **Used by:** • [Others SC Down](#) - x • [Others SC Mid](#) - x

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#88 F,A	**R Raw Material** (product circ index/Year) = (Recycled Raw Material Producer/3)/Linear Time **Present in 1 view:** • View 1 **Used by:** • Others SC Up - x • Recycled Raw Material Producer - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#89 F,A	**R Raw Material 4** (product circ index/Year) = (Recycled Raw Material Producer/6)/Linear Time **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Manufacturing • Recycled Raw Material Producer - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#90 L	**Recycled Raw Material Producer** (product circ index) = ∫(PCP3+PCP4-R Raw Material-R Raw Material 4) *dt* + [VCrea Output Rate*MSD Output Rate*Supply PCP BP rate] **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • R Raw Material • R Raw Material 4 - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#91 F,A	**Reg Change Rate** (product circ index/Year) = Regulation/CR R Average delay time **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Barriers - x • Brandowner involvement - x • ES Input Rate • Incentives - x • IS Input Rate - x • PCP BP - x • Reg Context and Complexity Change Rate - x • Regulation - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#92 F,A	**Reg Context and Complexity Change Rate** (product circ index/Year) = MIN (0.9, (Brandowner involvement+Natural Resource1+Reg Change Rate)/CCC Average delay time) **Description:** *x* **Present in 1 view:**

			• [View 1](#) **Used by:** • [Natural Resource1](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#93 L	**Regulation** (product circ index) = ∫[Context and Complexity Change Rate](#)-[Reg Change Rate](#) *dt* + [0] **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [Context and Complexity Change Rate](#) • [Reg Change Rate](#) - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#94 L	**Retail** (product circ index) = ∫[AFTM Product](#)+[Product2](#)-[Product 3](#)-[PCP7](#) *dt* + [[Supply PCP BP rate](#)] **Description:** *x* **Present in 1 view:** • [View 1](#) **Used by:** • [PCP7](#) • [Product 3](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#95 L	**Reverse logistics** (product circ index) = ∫(MIN (0.95, ([PCP1](#)+[PCP7](#)+[Supply PCP BP rate](#))))-([PCP 6](#)+[PCP4](#)+[PCP5](#)) *dt* + [0] **Present in 1 view:** • [View 1](#) **Used by:** • [Network Average Circularity](#) • [PCP 6](#) • [PCP4](#) • [PCP5](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#96 L	**Reverse Schemata** (product circ index) = ∫[RS Input Rate](#)-[RS Output Rate](#) *dt* + [0] **Present in 1 view:** • [View 1](#) **Used by:** • [RS Input Rate](#) • [RS Output Rate](#)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#97 SM,F	**RS Input Rate** (product circ index/Year) = SMOOTH([Agents position](#)+[Agents Role](#)*[Reverse Schemata](#), [IS Average Delay Time](#)) **Present in 1 view:**

			• View 1 **Used by:** • Reverse Schemata
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#98 F,A	**RS Output Rate** (product circ index/Year) = Reverse Schemata/Actions average life time **Present in 1 view:** • View 1 **Used by:** • Reverse Schemata • VCap Input Rate • VCrea Input Rate
Default	Control	#99 A	**SAVEPER** (Year [0,?]) = TIME STEP **Description:** *The frequency with which output is stored.* **Not Present In Any View**
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#100 F,A	**Sourcing strategy** (product circ index/Year) = MIN (0.95, SMOOTH(Supplier selection+MSD Output Rate, Strategy Average Delay Time)) **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Supplier and customer selection process are connected - x • Supplier selection - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#101 C	**Strategy Average Delay Time** (Year) = 1 **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Sourcing strategy - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#102 A	**Supplier and customer selection process are connected** (product circ index/Year) = Manage Agents as Customer and Suppliers at Same Time merging sourcing and customer strategy*Sourcing strategy **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Manage collection process

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#103 L	**Supplier selection** (product circ index) = ∫(Sourcing strategy)-Supply PCP BP rate *dt* + [0] **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Preferred Suppliers List - x • Sourcing strategy - x • Supply PCP BP rate - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#104 C	**Supply hybrid leadership** (product circ index) = 0.077 **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • MTSM Input Rate
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#105 LI,F,A	**Supply PCP BP rate** (product circ index/Year) = MIN (0.9, Supplier selection+Increase Competitiveness Recovered Vs Primary/Leadership average delay time) **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • Focalcompany Brand owner - x • Manufacturing • Natural Resource1 - x • "Oil, Mining, Energy or Farming" - x • P R Raw Material Producer - x • Primary Raw Material producer - x • Recycled Raw Material Producer - x • Retail - x • Reverse logistics • Supplier selection - x • WPC - x
Default	Control	#106 C	**TIME STEP** (Year [0,?]) = 0.125 **Description:** *The time step for the simulation.* **Not Present In Any View** **Used by:** • SAVEPER - The frequency with which output is stored.
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#107 L	**Transactional leadership** (product circ index) = ∫Leadership Input Rate-Leadership Output Rate *dt* + [0] **Description:** *x* **Present in 1 view:** • View 1

			Used by: • Leadership Output Rate - x
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#108 L	**Value Capture** (product circ index) = ∫VCap Input Rate-VCap Output Rate *dt* + [Manage collection process*Leadership Output Rate] **Description:** *x* **Present in 1 view:** • View 1 **Used by:** • VCap Input Rate • VCap Output Rate
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#109 C	**Value capture life time** (Year) = 12 **Present in 1 view:** • View 1 **Used by:** • VCap Output Rate
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#110 L	**Value Creation** (product circ index) = ∫Leadership Output Rate+VCrea Input Rate-VCrea Output Rate *dt* + [Manage collection process] **Present in 1 view:** • View 1 **Used by:** • VCrea Input Rate • VCrea Output Rate
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#111 C	**VCap Average Delay Time** (Year) = 8 **Present in 1 view:** • View 1 **Used by:** • VCap Input Rate
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#112 SM,F	**VCap Input Rate** (product circ index/Year) = SMOOTH(Initiating Mechanisms+Value Capture*RS Output Rate, VCap Average Delay Time) **Present in 1 view:** • View 1 **Used by:** • Value Capture - x

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#113 LI,F,A	**VCap Output Rate** (product circ index/Year)
			= Value Capture/Value capture life time
			Present in 1 view:
			
			   • View 1
			
			Used by:
			
			   • Value Capture - x
			   • WPC - x

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#114 C	**VCrea Average Delay Time** (Year)
			= 2
			Present in 1 view:
			
			   • View 1
			
			Used by:
			
			   • VCrea Input Rate

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#115 SM,F	**VCrea Input Rate** (product circ index/Year)
			= SMOOTH(Coordination Mechanisms+Value Creation*RS Output Rate, VCrea Average Delay Time)
			Present in 1 view:
			
			   • View 1
			
			Used by:
			
			   • Value Creation

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#116 LI,F,A	**VCrea Output Rate** (product circ index/Year)
			= Value Creation/Actions average life time
			Present in 1 view:
			
			   • View 1
			
			Used by:
			
			   • Focalcompany Brand owner - x
			   • Manufacturing
			   • "Oil, Mining, Energy or Farming" - x
			   • Recycled Raw Material Producer - x
			   • Value Creation

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation (Default)	#117 F,A	**Waste and PCP** (product circ index/Year)
			= MIN(0.92,"Final Consumers/Users"/Linear Time)
			Present in 1 view:
			
			   • View 1
			
			Used by:
			
			   • "Final Consumers/Users" - x
			   • GCS - x

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties	#118 L	**WPC** (product circ index) = ∫(PCP+PCP 8-PCP1-PCP2-PCP3) *dt* + [VCap Output Rate*MSD Output Rate*Leadership Output Rate*Supply PCP BP rate]

		Validation (Default)		**Description:** *x* **Present in 1 view:** • View 1 **Used by:** • PCP1 • PCP2 • PCP3 - x

Table 3 -List of 4 Variables Using IF...THEN...ELSE Functions

Module	Group	Type	*Variable* (4)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Barriers (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Brandowner involvement (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Incentives (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	PCP BP (product circ index/Year)

Table 4 - List of 17 Variables Using MIN or MAX Functions

Module	Group	Type	*Undocumented Variable* (17)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Context and Complexity Change Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	Leadership Output Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PCP (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PCP 8 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	PCP1 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PCP2 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PCP3 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	PCP4 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	PCP5 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	PCP7 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Product (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Product2 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Reg Context and Complexity Change Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Reverse logistics (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Sourcing strategy (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	Supply PCP BP rate (product circ index/Year)

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Waste and PCP (product circ index/Year)

Table 5 - List of 116 Variables Without Predefined Min or Max Values

Module	Group	Type	*Undocumented Variable* (116)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Actions average life time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	AFTM Product (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Agents position (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Agents Role (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Agents that Influence SN (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Average extraction fraction (1/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Barriers (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Brandowner involvement (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	CCC Average delay time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Complexity (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Context (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Context and Complexity Change Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Contingent reward (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Coordination Mechanisms (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	CR R Average delay time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Distribution (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	E Stakeholders (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	ES Average Delay Time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	DE,F	ES Input Rate (product circ index/Year)

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	ES O average delay time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	ES Output Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Extraction Change Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	"Final Consumers/Users" (product circ index)
Default	Control	C	FINAL TIME (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Focalcompany Brand owner (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	From IEE NR (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	GCS (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	I Stakeholders (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Incentives (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Increase Competitiveness Recovered Vs Primary (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Increasse Society And government Involvement (product circ index)
Default	Control	C	INITIAL TIME (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Initiating Mechanisms (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	IS Average Delay Time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	IS Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	IS Output Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	ISO Average delay time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Landfill (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Leadership average delay time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	DE,F	Leadership Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	Leadership Output Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Linear Time (Year)

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Main agents in SN (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Manage Agents as Customer and Suppliers at Same Time merging sourcing and customer strategy (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Manage by exception (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,A	Manage collection process (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Manufacturing (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	MSD Output Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	MTSM Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	multitier manag average delay time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Multitier Supplier Development (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Multitier supply management (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Natural Resource (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Natural Resource1 (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Network Average Circularity (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Non Linear Time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	"Oil, Mining, Energy or Farming" (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Others SC Down (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Others SC Mid (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Others SC Up (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	P R Raw Material 3 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	P R Raw Material OI Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	P R Raw Material Producer (product circ index)

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	P Raw Material (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	P Raw Material Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PCP (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	PCP 6 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PCP 8 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	PCP BP (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	PCP1 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PCP2 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PCP3 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	PCP4 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	PCP5 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	PCP7 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	People Cultural and Behavioral Differences (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PR Raw Material (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PR Raw Material 2 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PR Raw Material Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Preferred Suppliers List (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Primary Raw Material producer (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Product (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Product 1 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Product 3 (product circ index/Year)

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Product 4 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Product2 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Products (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	R Raw Material (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	R Raw Material 4 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Recycled Raw Material Producer (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Reg Change Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Reg Context and Complexity Change Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Regulation (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Retail (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Reverse logistics (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Reverse Schemata (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	RS Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	RS Output Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Sourcing strategy (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Strategy Average Delay Time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Supplier and customer selection process are connected (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Supplier selection (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Supply hybrid leadership (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	Supply PCP BP rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Transactional leadership (product circ index)

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Value Capture (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	Value capture life time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Value Creation (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	VCap Average Delay Time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	VCap Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	VCap Output Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	C	VCrea Average Delay Time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	VCrea Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	VCrea Output Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Waste and PCP (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	WPC (product circ index)

Table 6 - Formulation Complexity Summary (Violations of Richardson's Rule)

Module	Group	Type	Variable	Complexity Score
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Value Capture (product circ index)	4
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Others SC Up (product circ index)	4
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	MTSM Input Rate (product circ index/Year)	4
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Value Creation (product circ index)	4
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	VCrea Input Rate (product circ index/Year)	4
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	VCap Input Rate (product circ index/Year)	4
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Context and Complexity Change Rate (product circ index/Year)	4

Table 7 - List of 33 Equations with Embedded Data (0 and 1 constants ignored)

Module	Group	Type	*Variable* (33)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	AFTM Product (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Agents that Influence SN (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	Context and Complexity Change Rate (product circ index/Year)

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Increasse Society And government Involvement (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	Leadership Output Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Linear Time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Main agents in SN (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Network Average Circularity (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	A	Non Linear Time (Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	P R Raw Material OI Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	P Raw Material (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PCP (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PCP 8 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	PCP1 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PCP2 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	F,A	PCP3 (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	LI,F,A	PCP4 (product circ index/Year)

Table 8 - List of 32 State Variables

Module	Group	Type	Variable
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Distribution (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	E Stakeholders (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	DE,F	ES Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	"Final Consumers/Users" (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Focalcompany Brand owner (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	GCS (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	I Stakeholders (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	IS Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	DE,F	Leadership Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Manufacturing (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	MTSM Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Multitier Supplier Development (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Natural Resource1 (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	"Oil, Mining, Energy or Farming" (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Others SC Down (product circ index)

Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Others SC Mid (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Others SC Up (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	P R Raw Material Producer (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Primary Raw Material producer (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Recycled Raw Material Producer (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Regulation (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Retail (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Reverse logistics (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Reverse Schemata (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	RS Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Supplier selection (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Transactional leadership (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Value Capture (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	Value Creation (product circ index)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	VCap Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	SM,F	VCrea Input Rate (product circ index/Year)
Default	Thesis V28 Manag Mecha-Int Ext Environ-Emergent properties Validation	L	WPC (product circ index)

Table 9 - List of 1 View and Its 118 Variables

	View 1	
Total:	**130**	**:Total**
Actions average life time (in 1 view)		Actions average life time (in 1 view)
AFTM Product (in 1 view)		AFTM Product (in 1 view)
Agents position (in 1 view)		Agents position (in 1 view)
Agents Role (in 1 view)		Agents Role (in 1 view)
Agents that Influence SN (in 1 view)		Agents that Influence SN (in 1 view)
Average extraction fraction (in 1 view)		Average extraction fraction (in 1 view)
Barriers (in 1 view)		Barriers (in 1 view)
Brandowner involvement (in 1 view)		Brandowner involvement (in 1 view)
CCC Average delay time (in 1 view)		CCC Average delay time (in 1 view)
Complexity (in 1 view)		Complexity (in 1 view)
Context (in 1 view)		Context (in 1 view)
Context and Complexity Change Rate (in 1 view)		Context and Complexity Change Rate (in 1 view)
Contingent reward (in 1 view)		Contingent reward (in 1 view)
Coordination Mechanisms (in 1 view)		Coordination Mechanisms (in 1 view)
CR R Average delay time (in 1 view)		CR R Average delay time (in 1 view)
Distribution (in 1 view)		Distribution (in 1 view)
E Stakeholders (in 1 view)		E Stakeholders (in 1 view)
ES Average Delay Time (in 1 view)		ES Average Delay Time (in 1 view)
ES Input Rate (in 1 view)		ES Input Rate (in 1 view)
ES O average delay time (in 1 view)		ES O average delay time (in 1 view)
ES Output Rate (in 1 view)		ES Output Rate (in 1 view)

Preferred Suppliers List (in 1 view)		Preferred Suppliers List (in 1 view)
Primary Raw Material producer (in 1 view)		Primary Raw Material producer (in 1 view)
Product (in 1 view)		Product (in 1 view)
Product 1 (in 1 view)		Product 1 (in 1 view)
Product 3 (in 1 view)		Product 3 (in 1 view)
Product 4 (in 1 view)		Product 4 (in 1 view)
Product2 (in 1 view)		Product2 (in 1 view)
Products (in 1 view)		Products (in 1 view)
R Raw Material (in 1 view)		R Raw Material (in 1 view)
R Raw Material 4 (in 1 view)		R Raw Material 4 (in 1 view)
Recycled Raw Material Producer (in 1 view)		Recycled Raw Material Producer (in 1 view)
Reg Change Rate (in 1 view)		Reg Change Rate (in 1 view)
Reg Context and Complexity Change Rate (in 1 view)		Reg Context and Complexity Change Rate (in 1 view)
Regulation (in 1 view)		Regulation (in 1 view)
Retail (in 1 view)		Retail (in 1 view)
Reverse logistics (in 1 view)		Reverse logistics (in 1 view)
Reverse Schemata (in 1 view)		Reverse Schemata (in 1 view)
RS Input Rate (in 1 view)		RS Input Rate (in 1 view)
RS Output Rate (in 1 view)		RS Output Rate (in 1 view)
SAVEPER (in 0 views)		SAVEPER (in 0 views)
Sourcing strategy (in 1 view)		Sourcing strategy (in 1 view)
Strategy Average Delay Time (in 1 view)		Strategy Average Delay Time (in 1 view)
Supplier and customer selection process are connected (in 1 view)		Supplier and customer selection process are connected (in 1 view)
Supplier selection (in 1 view)		Supplier selection (in 1 view)
Supply hybrid leadership (in 1 view)		Supply hybrid leadership (in 1 view)
Supply PCP BP rate (in 1 view)		Supply PCP BP rate (in 1 view)
TIME STEP (in 0 views)		TIME STEP (in 0 views)
Transactional leadership (in 1 view)		Transactional leadership (in 1 view)
Value Capture (in 1 view)		Value Capture (in 1 view)
Value capture life time (in 1 view)		Value capture life time (in 1 view)
Value Creation (in 1 view)		Value Creation (in 1 view)
VCap Average Delay Time (in 1 view)		VCap Average Delay Time (in 1 view)
VCap Input Rate (in 1 view)		VCap Input Rate (in 1 view)
VCap Output Rate (in 1 view)		VCap Output Rate (in 1 view)
VCrea Average Delay Time (in 1 view)		VCrea Average Delay Time (in 1 view)
VCrea Input Rate (in 1 view)		VCrea Input Rate (in 1 view)
VCrea Output Rate (in 1 view)		VCrea Output Rate (in 1 view)
Waste and PCP (in 1 view)		Waste and PCP (in 1 view)
WPC (in 1 view)		WPC (in 1 view)
Total:	**130**	**:Total**
	View 1	

* **Includes *Time*, if used in a view. Excludes variables not present in any view.**

Level Structure †

Distribution = ∫(Product 1-Product2) *dt* + [0]
   Product 1 = Focalcompany Brand owner/Linear Time
   Product2 = MIN (0.92, Distribution/3/Linear Time)

E Stakeholders = ∫ES Input Rate-ES Output Rate *dt* + [0]
   ES Input Rate = DELAY1(((Agents that Influence SN*Reg Change Rate+Increasse Society And government Involvement+People Cultural and Behavioral Differences)-E Stakeholders), ES Average Delay Time)
   ES Output Rate = E Stakeholders/ES O average delay time

"Final Consumers/Users" = ∫(Product 3+PCP 8+Product 4)-(Waste and PCP+PCP1+PCP 8) *dt* + [0]
   PCP 8 = MIN(0.92, "Final Consumers/Users"/Non Linear Time)
   PCP1 = MIN(0.9,WPC/Non Linear Time)

Product 3 = Retail/Linear Time/3
Product 4 = Others SC Down/Linear Time
Waste and PCP = MIN(0.92,"Final Consumers/Users"/Linear Time)

Focalcompany Brand owner = ∫Product-Product 1 dt + [Leadership Output Rate*Supply PCP BP rate*MSD Output Rate*VCrea Output Rate]
Leadership Output Rate = MIN (0.92, Transactional leadership/Leadership average delay time)
MSD Output Rate = Multitier Supplier Development/Actions average life time
Supply PCP BP rate = MIN (0.9, Supplier selection+Increase Competitiveness Recovered Vs Primary/Leadership average delay time)
VCrea Output Rate = Value Creation/Actions average life time
    Product = MIN(0.95,Manufacturing/Linear Time)

GCS = ∫Waste and PCP-Landfill-PCP dt + [0]
    Landfill = GCS/Non Linear Time
    PCP = MIN(0.92,GCS/Non Linear Time)

I Stakeholders = ∫IS Input Rate-IS Output Rate dt + [0]
    IS Input Rate = SMOOTH(I Stakeholders*Reg Change Rate-Main agents in SN+Preferred Suppliers List, IS Average Delay Time)
    IS Output Rate = I Stakeholders/ISO Average delay time

Manufacturing = ∫P Raw Material+PR Raw Material+R Raw Material 4-AFTM Product-Product dt + [Leadership Output Rate*Supply PCP BP rate*MSD Output Rate*VCrea Output Rate]
    AFTM Product = Manufacturing/Linear Time/3
    P Raw Material = (Primary Raw Material producer/3)/Linear Time
    PR Raw Material = (P R Raw Material Producer/3)/Linear Time
    R Raw Material 4 = (Recycled Raw Material Producer/6)/Linear Time

Multitier Supplier Development = ∫MTSM Input Rate-MSD Output Rate dt + [0]
    MTSM Input Rate = SMOOTH(Multitier Supplier Development*Multitier supply management+Supply hybrid leadership, multitier manag average delay time)

Natural Resource1 = ∫Reg Context and Complexity Change Rate+Supply PCP BP rate-Extraction Change Rate dt + [0]
    Extraction Change Rate = Average extraction fraction*(Incentives-Barriers+PCP BP)*Natural Resource1
    Reg Context and Complexity Change Rate = MIN (0.9, (Brandowner involvement+Natural Resource1+Reg Change Rate)/CCC Average delay time)

"Oil, Mining, Energy or Farming" = ∫Natural Resource+PCP 6-P R Raw Material OI Rate-P Raw Material Rate-PR Raw Material Rate dt + [VCrea Output Rate*MSD Output Rate*Leadership Output Rate*Supply PCP BP rate]
    Natural Resource = From IEE NR/Linear Time
    P R Raw Material OI Rate = ("Oil, Mining, Energy or Farming"/3)/Linear Time
    P Raw Material Rate = "Oil, Mining, Energy or Farming"/Linear Time
    PCP 6 = Reverse logistics/Non Linear Time
    PR Raw Material Rate = ("Oil, Mining, Energy or Farming"/Linear Time)/3

Others SC Down = ∫Products-Product 4 dt + [0]
    Products = Others SC Mid/Linear Time

Others SC Mid = ∫P R Raw Material 3-Products dt + [0]
    P R Raw Material 3 = Others SC Up/Linear Time

Others SC Up = ∫P R Raw Material OI Rate+PR Raw Material 2+R Raw Material-P R Raw Material 3 dt + [0]
    PR Raw Material 2 = (P R Raw Material Producer/3)/Linear Time
    R Raw Material = (Recycled Raw Material Producer/3)/Linear Time

P R Raw Material Producer = ∫PR Raw Material Rate+PCP2+PCP5-PR Raw Material-PR Raw Material 2 dt + [Supply PCP BP rate]
    PCP2 = MIN(0.95,WPC/2/3/Non Linear Time)
    PCP5 = MIN(0.95,(DELAY1(Reverse logistics/3, Non Linear Time))/3/Non Linear Time)

Primary Raw Material producer = ∫P Raw Material Rate+Supply PCP BP rate-P Raw Material dt + [Supply PCP BP rate]

Recycled Raw Material Producer = ∫(PCP3+PCP4-R Raw Material-R Raw Material 4) *dt* + [VCrea Output Rate*MSD Output Rate*Supply PCP BP rate]
   PCP3 = MIN(0.9,DELAY1(WPC, Non Linear Time)/Non Linear Time)
   PCP4 = MIN(0.9,Reverse logistics/3/Non Linear Time)

Regulation = ∫Context and Complexity Change Rate-Reg Change Rate *dt* + [0]
   Context and Complexity Change Rate = MIN (0.92, (Complexity+Context+Regulation)/CCC Average delay time)
   Reg Change Rate = Regulation/CR R Average delay time

Retail = ∫AFTM Product+Product2-Product 3-PCP7 *dt* + [Supply PCP BP rate]
   PCP7 = MIN(0.9,Retail/Non Linear Time)

Reverse logistics = ∫(MIN (0.95, (PCP1+PCP7+Supply PCP BP rate)))-(PCP 6+PCP4+PCP5) *dt* + [0]

Reverse Schemata = ∫RS Input Rate-RS Output Rate *dt* + [0]
   RS Input Rate = SMOOTH(Agents position+Agents Role*Reverse Schemata, IS Average Delay Time)
   RS Output Rate = Reverse Schemata/Actions average life time

Supplier selection = ∫(Sourcing strategy)-Supply PCP BP rate *dt* + [0]
   Sourcing strategy = MIN (0.95, SMOOTH(Supplier selection+MSD Output Rate, Strategy Average Delay Time))

Transactional leadership = ∫Leadership Input Rate-Leadership Output Rate *dt* + [0]
   Leadership Input Rate = DELAY1(Contingent reward+Manage by exception+Agents Role+Agents position, Leadership average delay time)

Value Capture = ∫VCap Input Rate-VCap Output Rate *dt* + [Manage collection process*Leadership Output Rate]
Manage collection process = Supplier and customer selection process are connected
   VCap Input Rate = SMOOTH(Initiating Mechanisms+Value Capture*RS Output Rate, VCap Average Delay Time)
   VCap Output Rate = Value Capture/Value capture life time

Value Creation = ∫Leadership Output Rate+VCrea Input Rate-VCrea Output Rate *dt* + [Manage collection process]
   VCrea Input Rate = SMOOTH(Coordination Mechanisms+Value Creation*RS Output Rate, VCrea Average Delay Time)

WPC = ∫(PCP+PCP 8-PCP1-PCP2-PCP3) *dt* + [VCap Output Rate*MSD Output Rate*Leadership Output Rate*Supply PCP BP rate]

† *Level Structure Report* still under development.