Structural modelling: an application to the assessment of ecosystem practices at the plot level

Dominique Desbois

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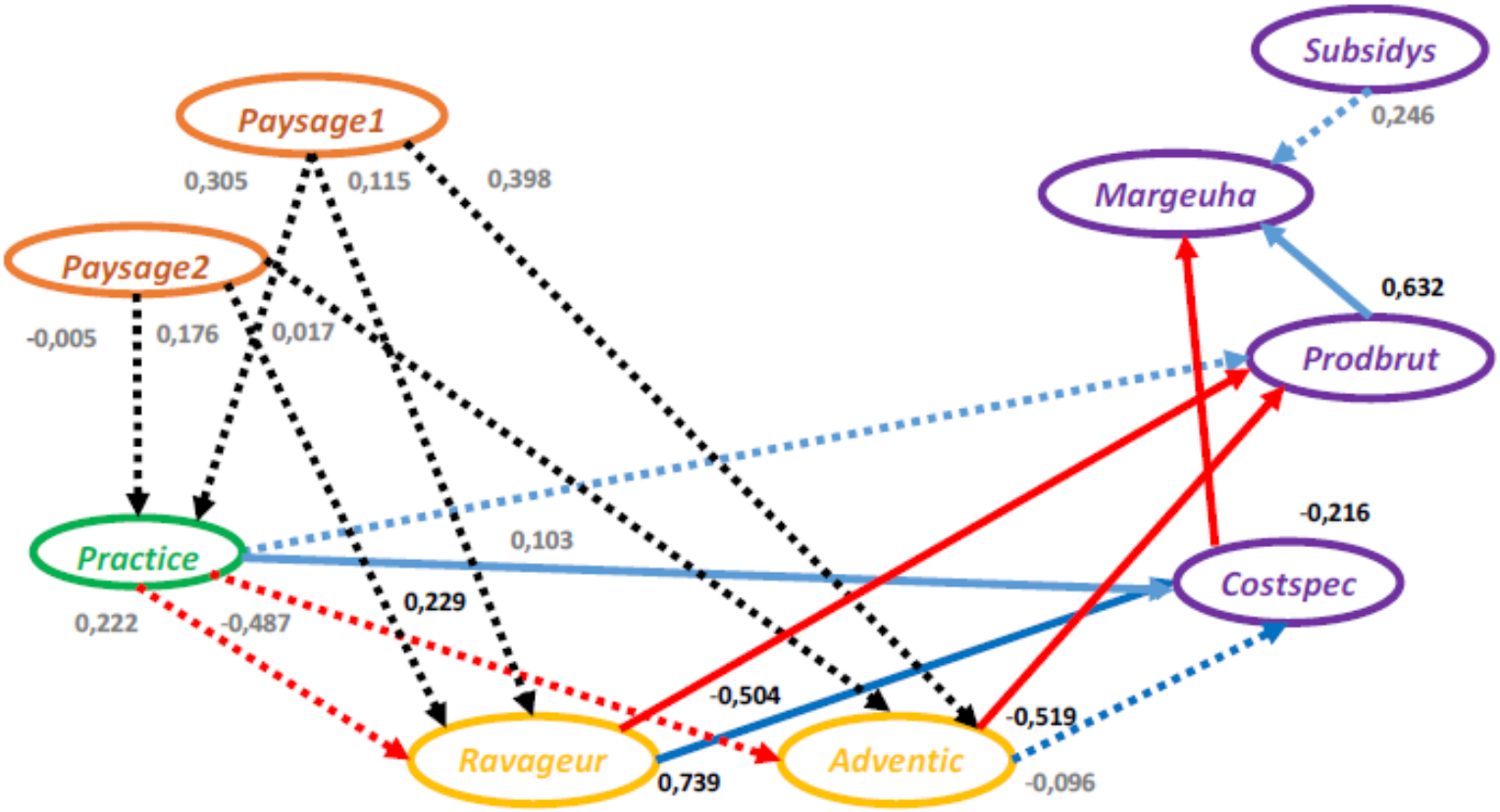
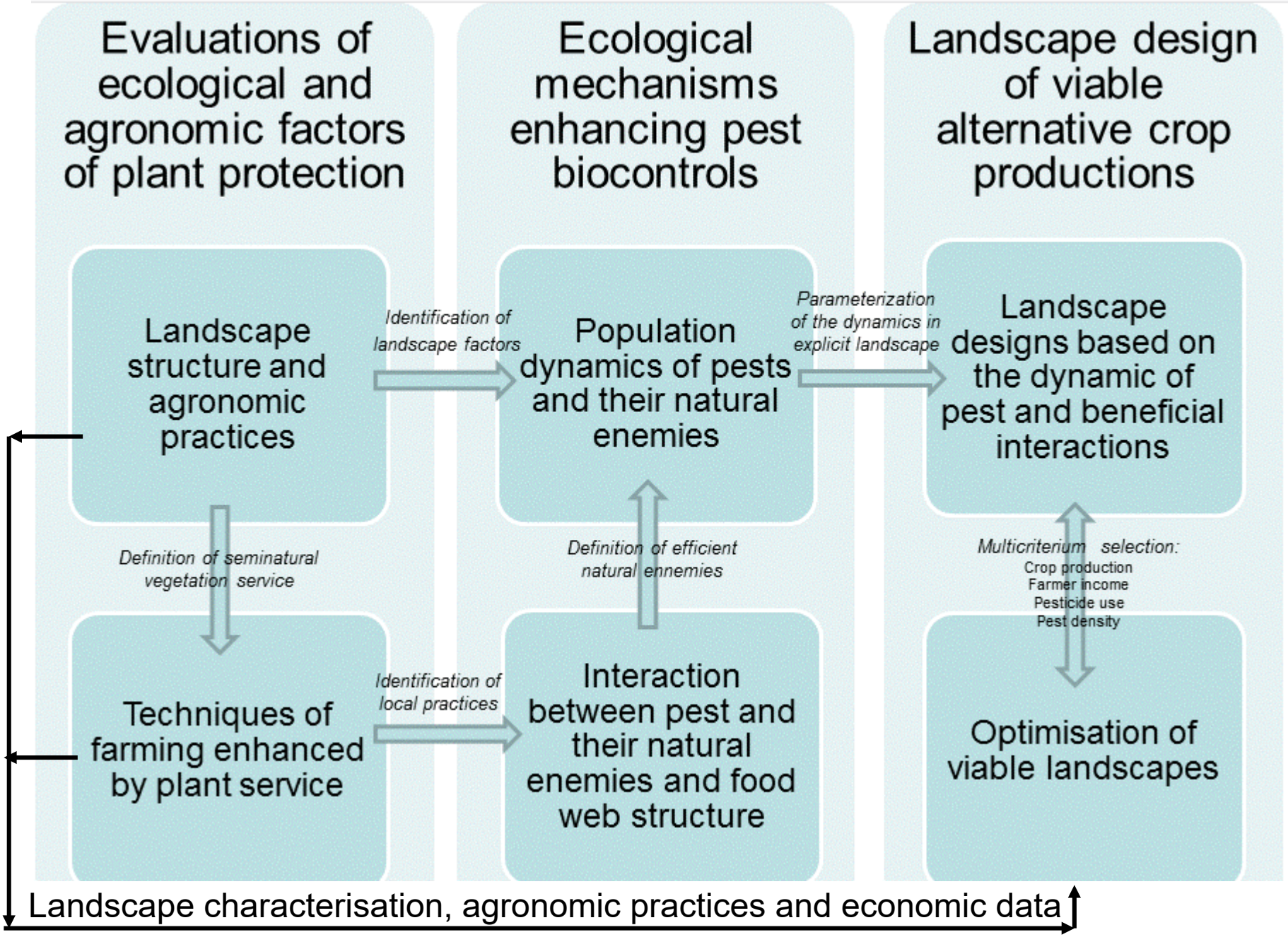


Dominique Desbois, UMR Économie publique, INRAE-AgroParisTech

Peerless agro-ecological context : relationships between ecological status, agronomic practices and economic results at the plot level



Peerless: location of agricultural plots

Plots of field crops in Ille et Vilaine

Plots of field crops in Maine et Loire

Plots of field crops in Côte d'Or

Orchard plots in Vaucluse

Peerless: type of variables (I)

Latent Variables	Manifest Variables	Data ecological	agronomic	economic
Landscape 1	*landscape diversity indicators*			
	Winter crop (% area)	√		
	Spring crop (% area)	√		
	Summer crop (% area)	√		
	Perennial crops (% area)	√		
	Fabaceae (% area)	√		
	Fallow land (% area)	√		
	Market gardening (% area)	√		
	Oilseeds (% area)	√		
	Wooded zones (% area)	√		
Landscape 2	*landscape diversity indicators*			
	Shannon index in field crops	√		
	Shannon index for all outputs	√		
Practice	*Agronomic practices*			
	Total treatment frequency index		√	
	Other treatment frequency index		√	
	Fungicide treatment frequency index		√	
	Herbicide treatment frequency index		√	
	Treatment frequency index excluding herbicides		√	
	Insecticide treatment frequency index		√	
	Treatment frequency index excluding seed treatment		√	
	Treatment frequency index seed treatment		√	
	Number of passages		√	
	Ploughing		√	
	Fertilisation yield target (t/ha)		√	
	Mineral nitrogen fertilisation (u.N/ha)		√	
	Organic nitrogen fertilisation (u.N/ha)		√	
	Number of mineral fertilisations		√	
	Number of organic fertilisations		√	
	Number of fertilisations		√	
	Deep tillage (Boolean)		√	
	Shallow tillage (Boolean)		√	
	Total tillage (hrs/ha)		√	
Pest	*Pests*			
	Sitobion avenae (cereal aphid)	√		
	M.dirhodul (cereal and rose aphid)	√		
	Total of aphids	√		
	Lema larvae (cereal leaf beetle)	√		
	Locust damage (%)	√		

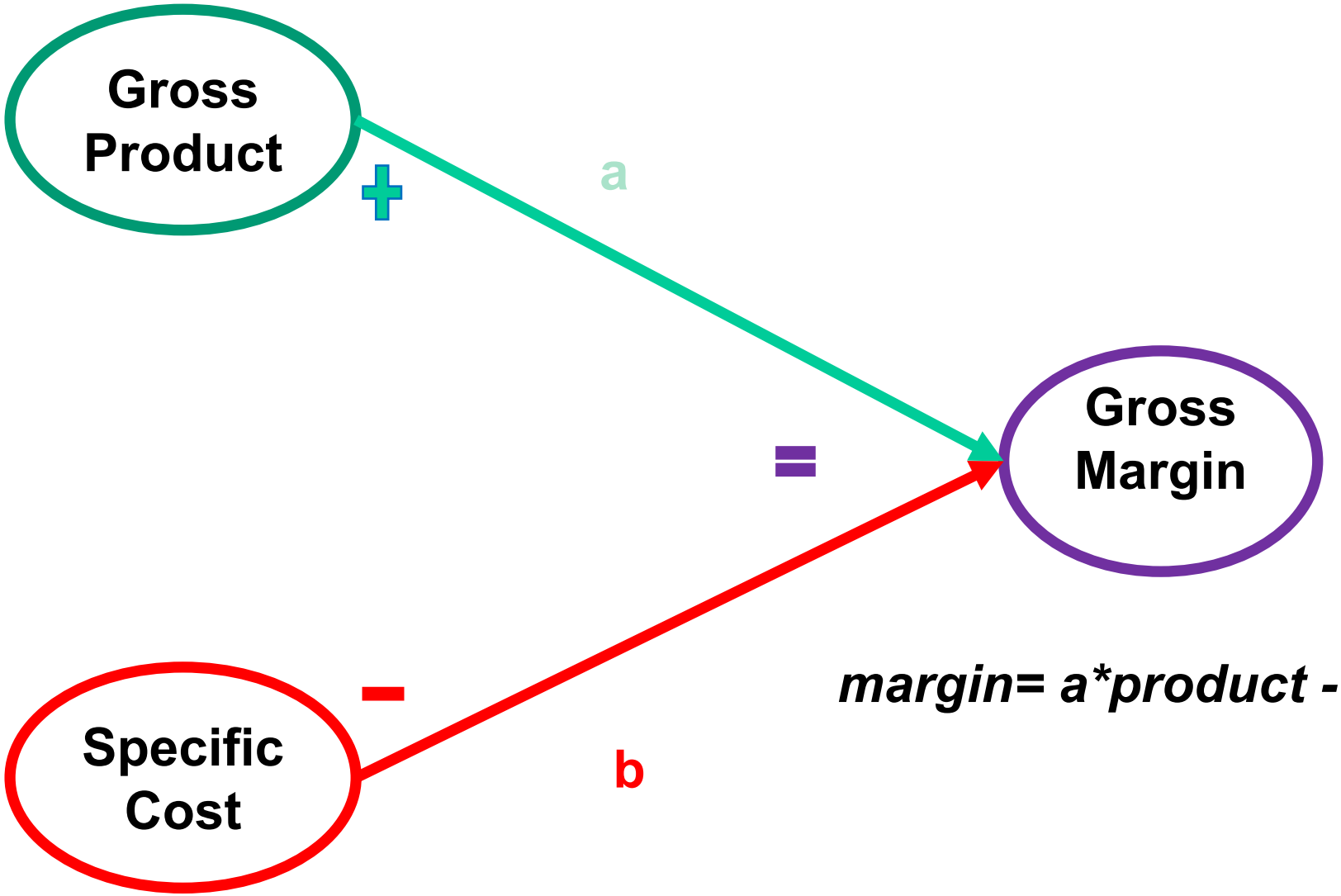
Peerless: type of variables (II)

Latent Variables	Manifest Variables	Data ecological	agronomic	economic
Adventice	*Adventices*			
	Total weed cover (%)	√		
	Dicotyledons (%)	√		
	Grasses (%)	√		
	Number of species	√		
	Percentage of area under dicotyledons (%)	√		
	Percentage of area under grasses (%)	√		
SpecCost	*Specific Costs*			
	Seeding costs (€/ha)			√
	Soil preparation costs (€/ha)			√
	Preparation and sowing costs (€/ha)			√
	Chemical and mechanical weed control costs (€/ha)			√
	Fungicide costs (€/ha)			√
	Insecticide and mollucide costs (€/ha)			√
	Plant protection costs (€/ha)			√
	Fertiliser costs (€/ha)			√
	Harvest costs (€/ha)			√
	Total specific costs (€/ha)			√
GrossProd	*Gross Product*			
	Observed yields (t/ha)		√	√
	¨Price (€/t)			√
	¨Main output (€/ha)			√
	¨Total output (€/ha)			√
Subsidys	*Subsidies*			
	Single payment scheme (€/ha)			√
	Coupled aid (€/ha)			√
	Organic farming support (€/ha)			√
	Total aid (€/ha)			√
Marginuha	*Unit margin per hectare*			
	Gross margin per unit (€/ha)			√
	Gross margin including SFP (€/ha)			√
	Standard gross margin (€/ha)			√

Structural model: the simplified example of the farm margin

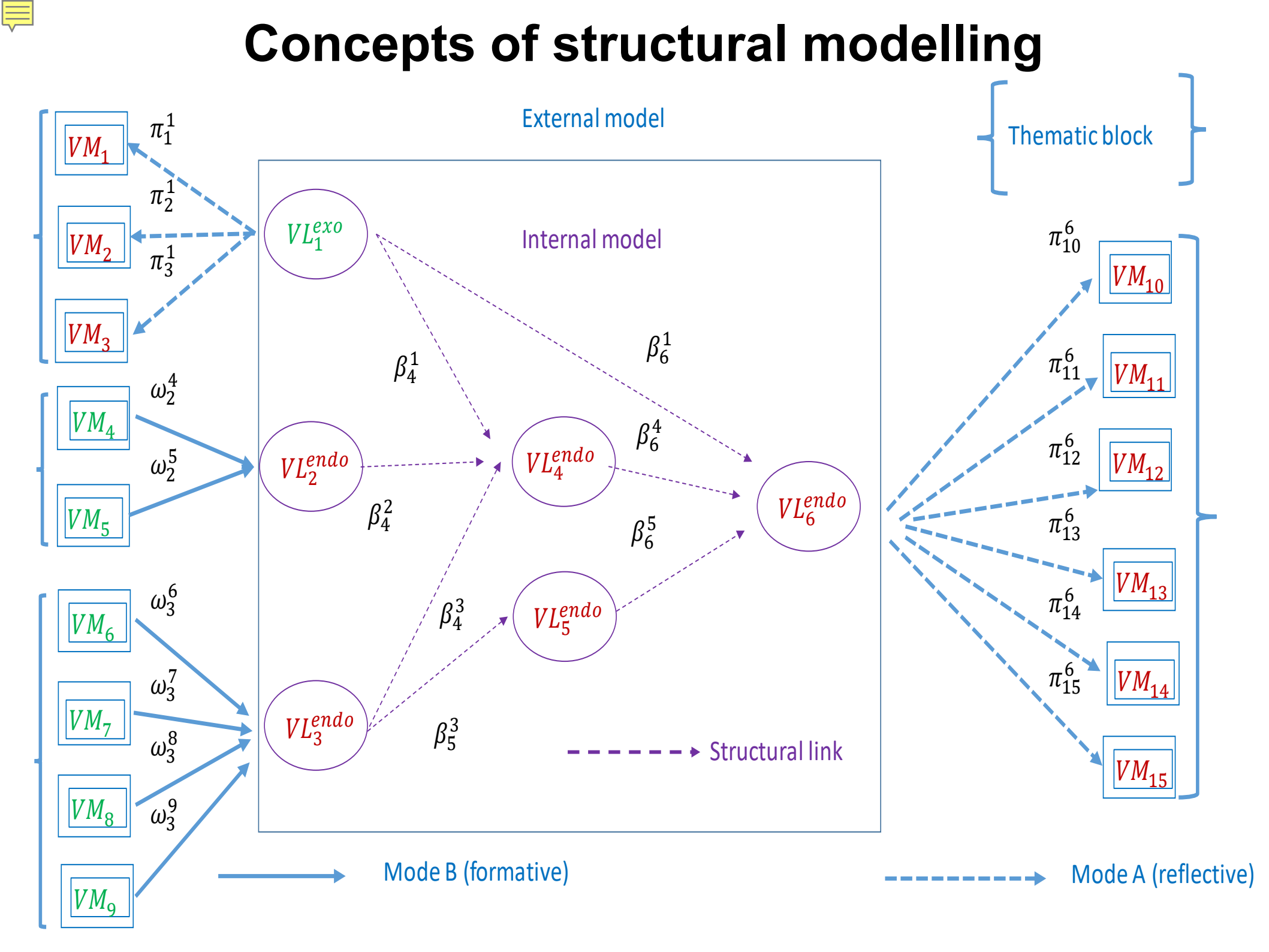
The gross margin of a farm holding depends on its gross product but also on its production costs.

Let the structural equation be: ***margin = f(product, cost)***

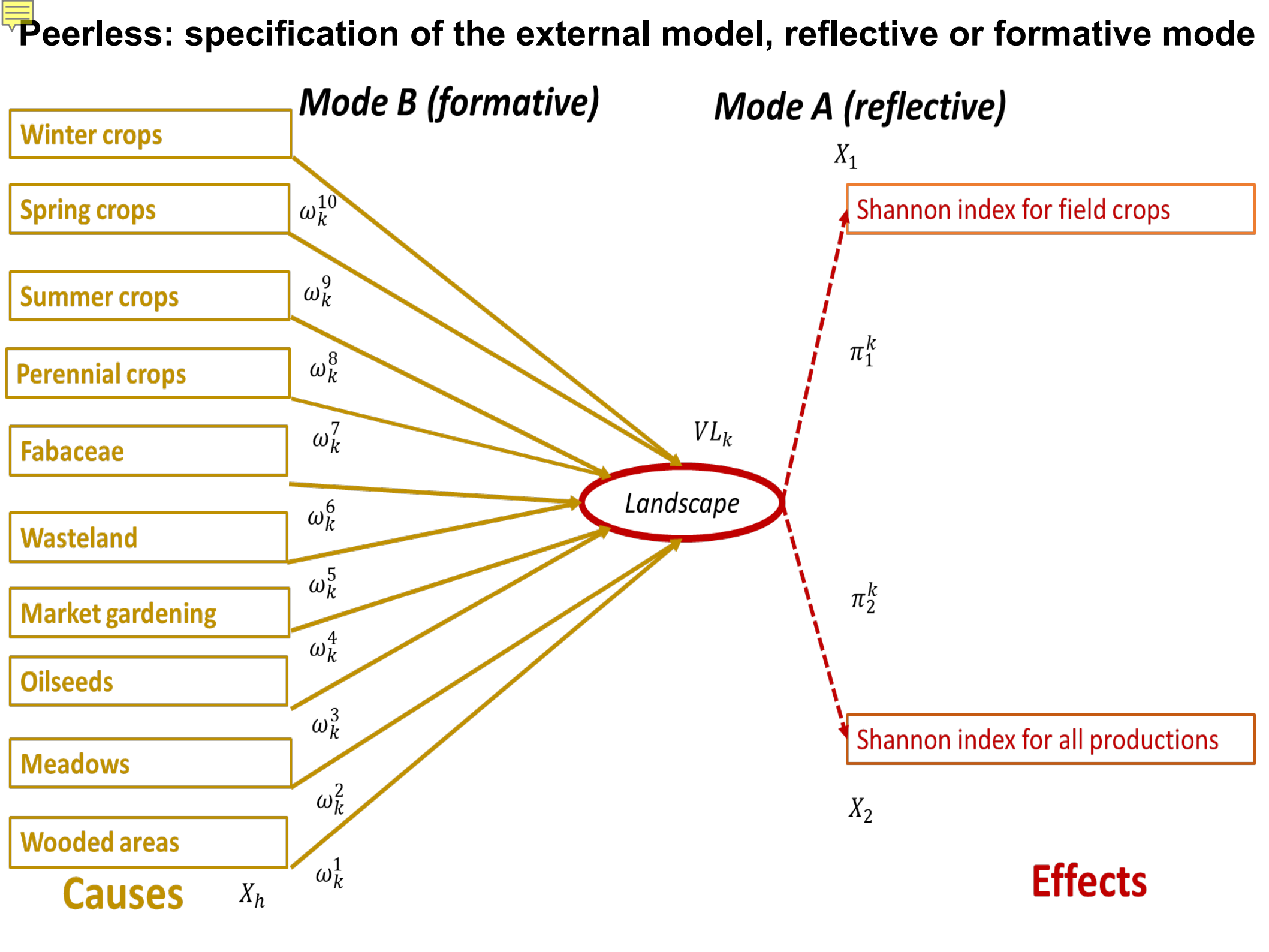


margin= a*product - b*cost

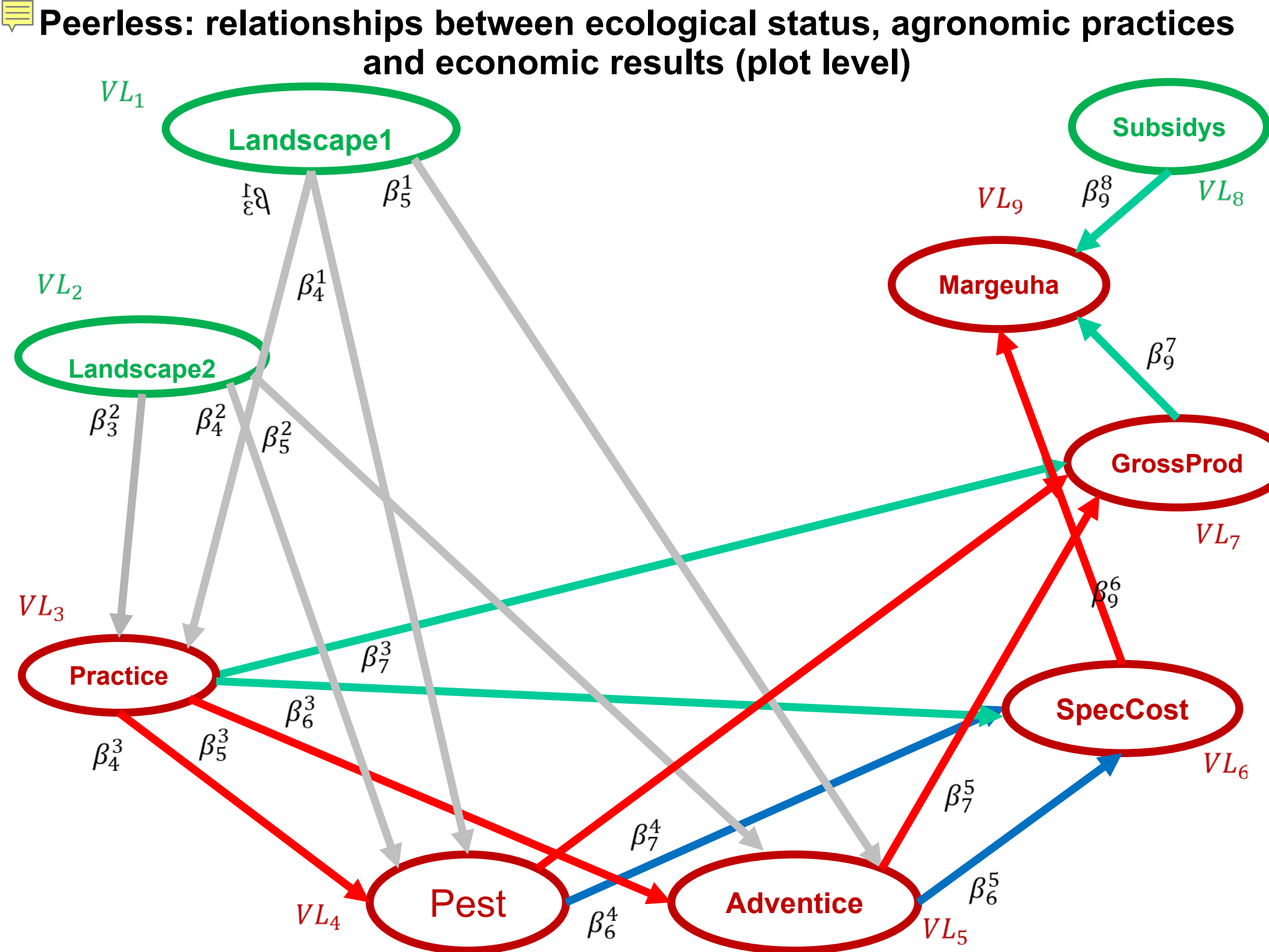
Concepts of structural modelling



Peerless: specification of the external model, reflective or formative mode



Peerless: relationships between ecological status, agronomic practices and economic results (plot level)



PLS-PM: structural model estimation procedure

```
# loading the pls-pm package
library(plspm)
```

Structure of the results obtained:

```
Partial Least Squares Path Modeling (PLS-PM)
-----------------------------------------------------------------------
## NAME                    DESCRIPTION
##      1 $outer_model      outer model
##      2 $inner_model      inner model
##      3 $path_coefs       path coefficients matrix
##      4 $scores           latent variable scores
##      5 $crossloadings    cross-loadings
##      6 $inner_summary    summary inner model
##      7 $effects          total effects
##      8 $unidim           unidimensionality
##      9 $gof              goodness-of-fit
##      10 $boot            bootstrap results
##      11 $data            data matrix
-----------------------------------------------------------------------
```

```
# R Source
http://cran.r-project.org/web/packages/plspm/index.html
```

Uni-dimensionnality Statistics : values of the initial coding

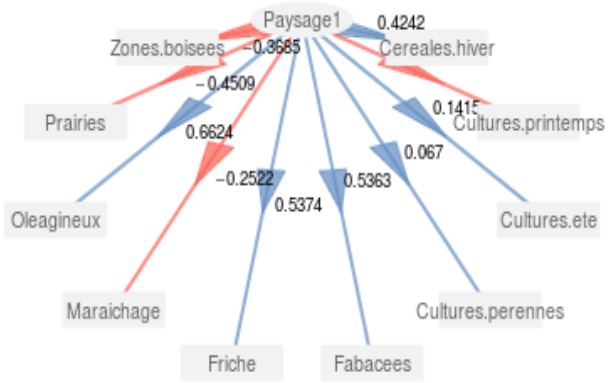
Blocks	Mode	Observed Var	Cronbach's Alpha	Dillon-Goldstein's Rho	Eigenvalue 1	Eigenvalue 2
Landscape1	A	9	0.398	0.073	2.04	1.67
Landscape2	A	10	0.473	0.642	1.84	1.45
Practice	A	18	0.943	0.950	9.45	3.20
Pest	A	5	0.807	0.874	3.03	0.96
Adventice	A	6	0.871	0.904	3.68	1.09
SpecCost	A	10	0.834	0.879	4.75	2.30
GrossProd	A	4	0.690	0.805	2.30	1.59
Subsidys	A	4	0.243	0.125	2.09	0.18
Margeuha	A	3	0.986	0.991	2.92	0.07

The unidimensionality statistics (**Cronbach's Alpha** and **Dillon-Goldstein's Rho**) based on this external scheme show too low values (far from the **0.7 threshold**) for the thematic blocks:

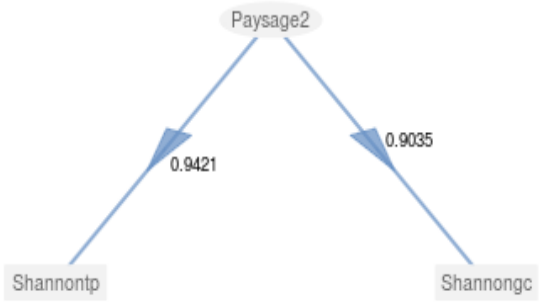
Subsidys (subsidies) ;
Landscape 1 & 2 (plot complexity);

Peerless: initial external model

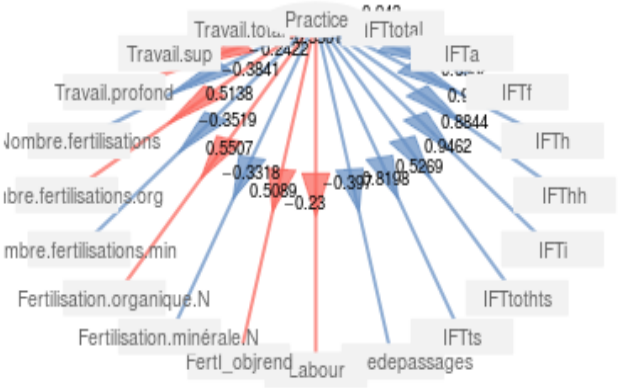
Paysage1 loadings



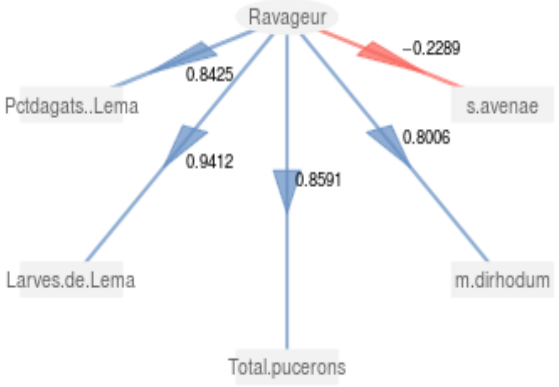
Paysage2 loadings



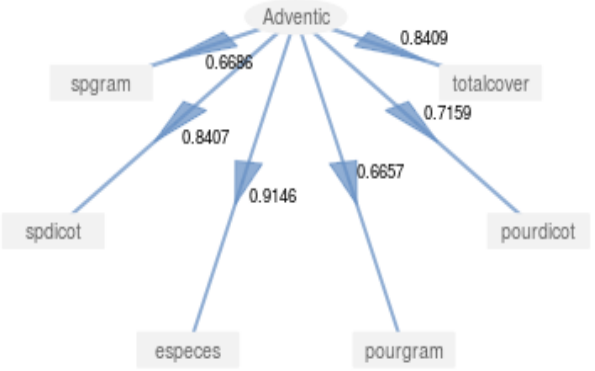
Practice loadings



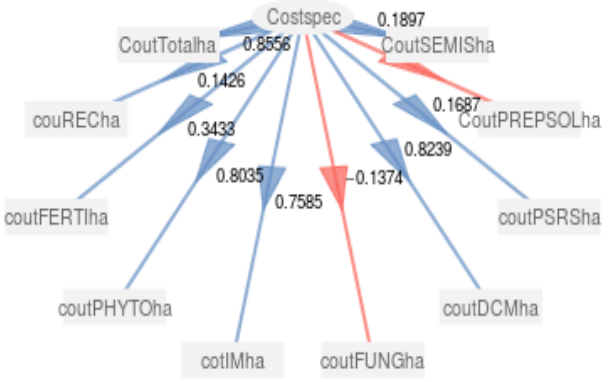
Ravageur loadings



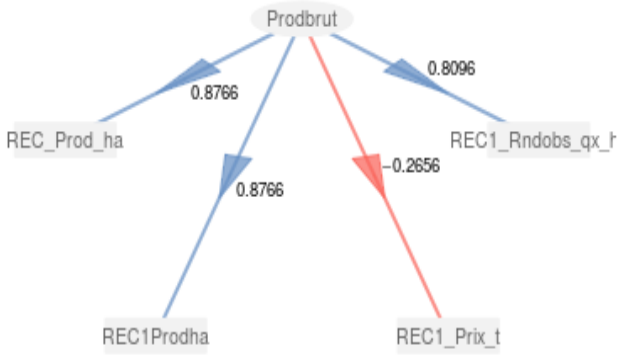
Adventic loadings



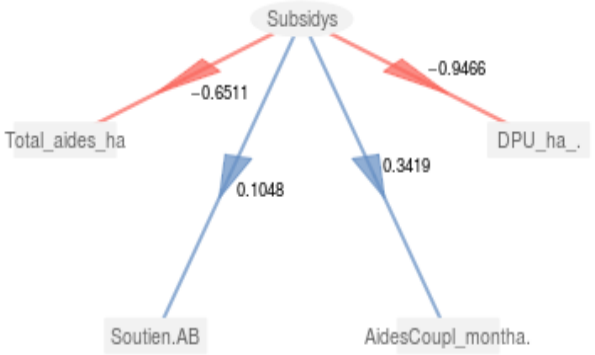
Costspec loadings



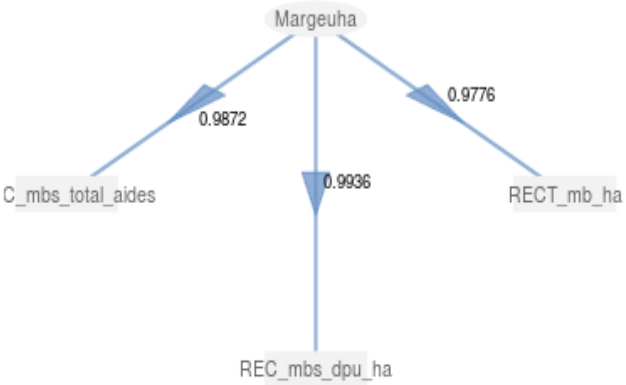
Prodbrut loadings



Subsidys loadings



Margeuha loadings



Uni-dimensionnality Statistics : values after variable recoding

Blocks	Mode	Observed Var	Cronbach's Alpha	Dillon-Goldstein's Rho	Eigenvalue 1	Eigenvalue 2
Landscape1	A	10	0	0.215	2.10	1,79
Landscape2	A	2	0.829	0.921	1.71	0.29
Practice	A	19	0.720	0.741	9.11	3.33
Pest	A	5	0.717	0.838	3.03	0.96
Adventice	A	6	0.871	0.904	3.68	1.09
SpecCost	A	10	0.541	0.611	3.02	2.50
GrossProd	A	4	0.592	0.790	2.30	1.59
Subsidys	A	4	0.664	0.804	2.08	1.31
Margeuha	A	3	0.986	0.991	2.92	0.07

After appropriate recoding of some variables of the blocks, the uni-dimensionality statistics have improved:

for **Cronbach's Alpha**

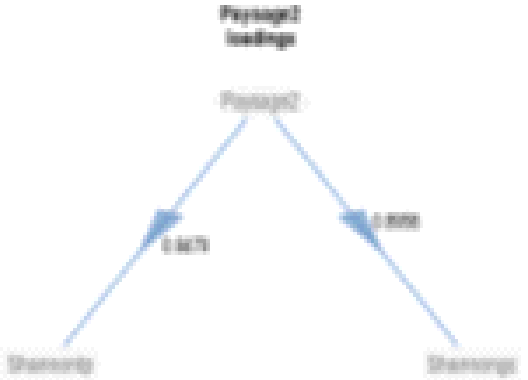
the values are all higher than 0.5 except for the **Landscape1** block ;

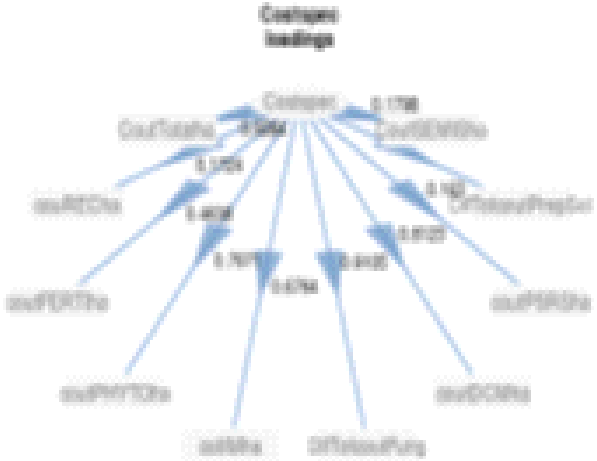
with values below 0.7 for the **SpecCost**, **GrossProd**, **Subsidys** blocks ;

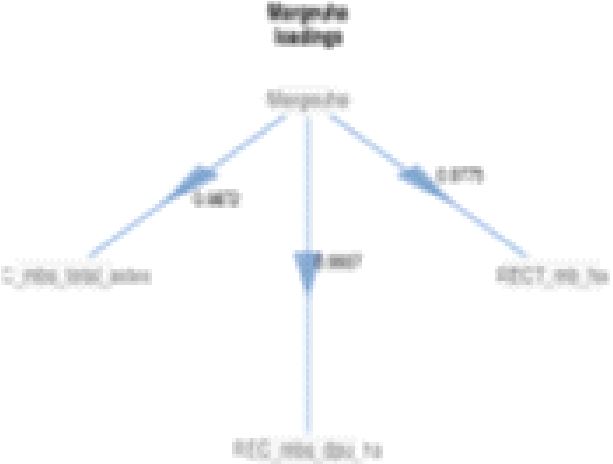
for **Dillon-Goldstein's Rho**

the values are all higher than 0.6 except for **Landscape1**.

Peerless: amended external model







Goddness of Fit : communalities, R^2 and redundancies

Theme block	Manifest variables	Communality	Type	R^2	Average redundancy
Landscape1	9	0.178	Exogeneous	0.0000	0.0000
Landscape2	2	0.850	Exogeneous	0.0000	0.0000
Practice	18	0.517	Endogeneous	0.0921	0.0477
Pest	5	0.606	Endogeneous	0.1254	0.0759
Adventice	6	0.608	Endogeneous	0.2806	0.1707
SpecCost	10	0.462	Endogeneous	0.6764	0.3127
GrossProd	4	0.542	Endogeneous	0.6906	0.3746
Subsidys	4	0.362	Exogeneous	0.0000	0.0000
Margeinuha	3	0.972	Endogeneous	0.6391	0.6215
Weighted Mean		0.499			
Endogenous block Mean		0.618		0.417	0.2579
Goodness of fit (GoF)				0.5078	

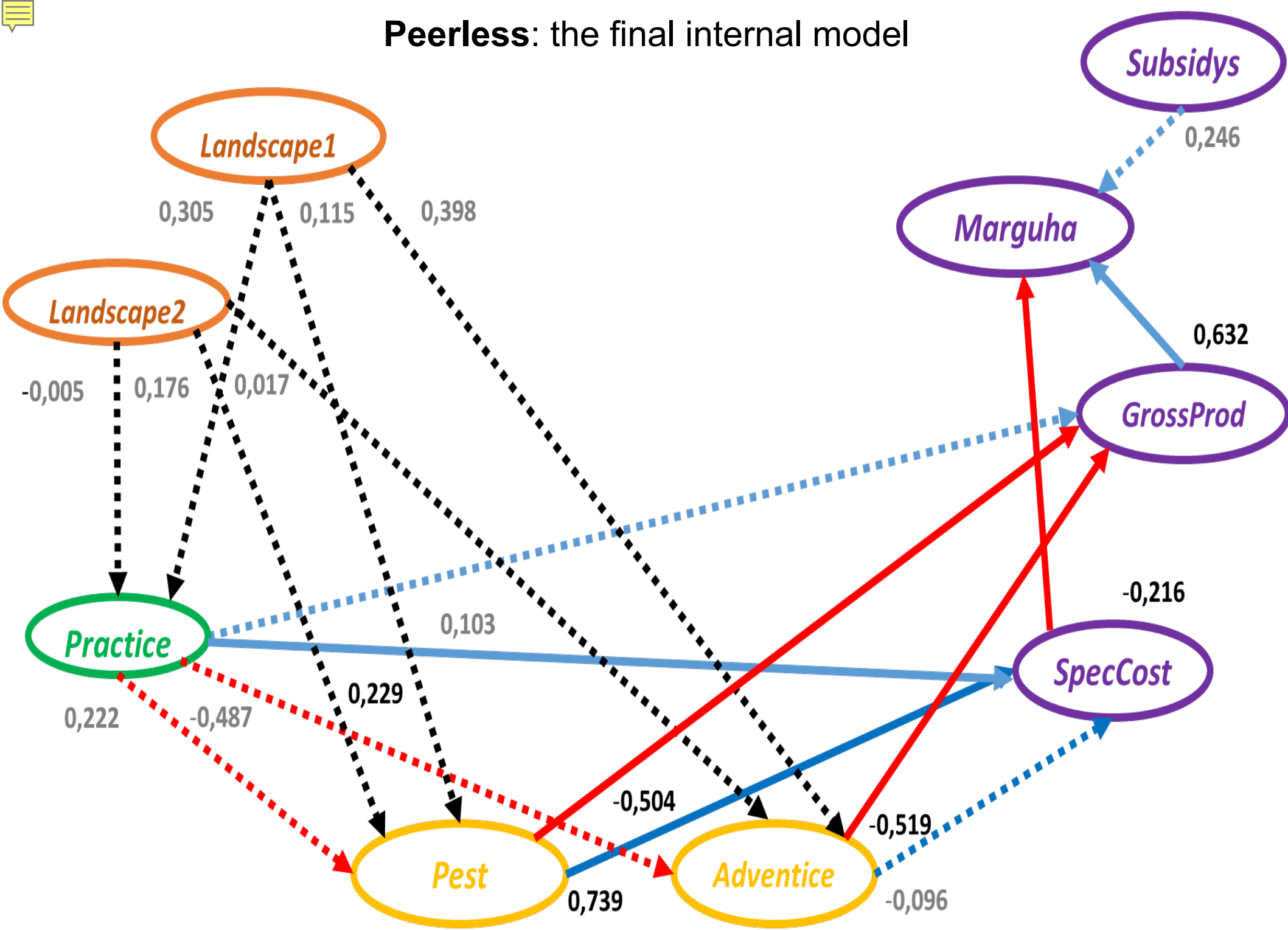
The **GoF value**, the overall indicator of the goodness of fit of the amended model, improves quite marginally, reaching **0.5078** .

Structural Links of the Model: bootstrap estimates

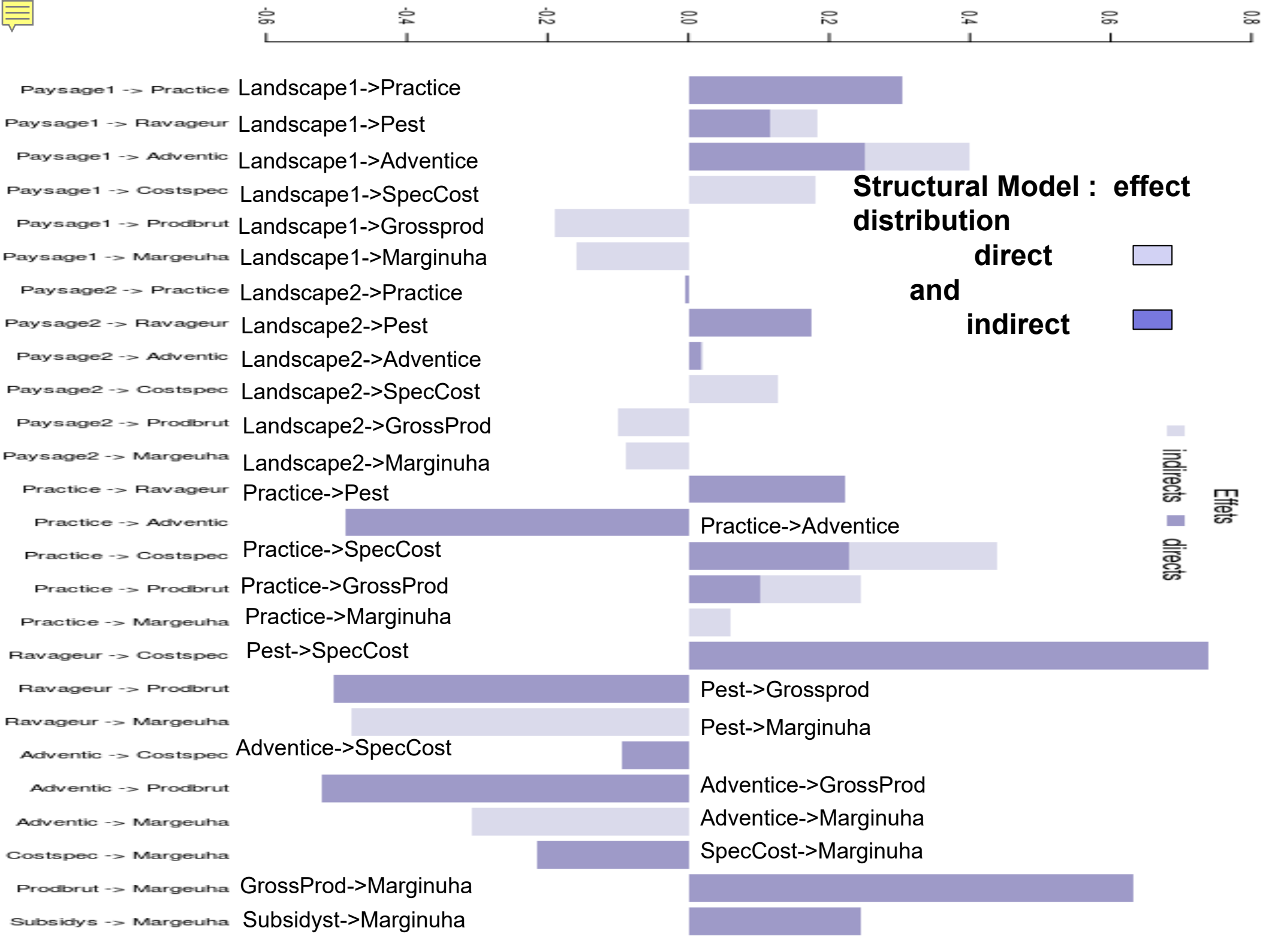
Link	Estimate	Bootstrap Estimate	Standard-error	Q(0.025)	Q(0.975)
Landscape1 -> Practice	0.305	0.249	0.323	-0.521	0.639
Landscape1 -> Pest	0.115	0.203	0.251	-0.380	0.552
Landscape1 -> Adventice	0.398	0.431	0.215	-0.227	0.692
Landscape2 -> Practice	-0.005	-0.045	0.188	-0.365	0.297
Landscape2 -> Pest	0.176	0.175	0.120	-0.031	0.359
Landscape2 -> Adventice	0.017	0.017	0.122	-0.233	0.197
Practice -> Pest	0.222	0.182	0.180	-0.186	0.499
Practice -> Adventice	-0.487	-0.478	0.209	-0.748	0.097
Practice -> SpecCost	**0.229**	**0.247**	**0.159**	**0.016**	**0.451**
Practice -> GrossProd	0.103	0.071	0.131	-0.239	0.234
Pest -> SpecCost	**0.739**	**0.706**	**0.115**	**0.496**	**0.893**
Pest -> GrossProd	**-0.504**	**-0.482**	**0.098**	**-0.651**	**-0.255**
Adventice -> SpecCost	-0.096	-0.100	0.139	-0.400	0.156
Adventice -> GrossProd	**-0.519**	**-0.506**	**0.118**	**-0.640**	**-0.329**
SpecCost -> Margeuha	**-0.216**	**-0.204**	**0.079**	**-0.341**	**-0.015**
GrossProd -> Margeuha	**0.632**	**0.688**	**0.107**	**0.482**	**0.896**
Subsidys -> Margeuha	0.246	0.129	0.227	-0.390	0.447

Values in **blue** denote estimates that are significantly different from zero

Peerless: the final internal model



Statistically significant structural relationships in the model are shown in **solid lines** and their values are indicated in **bold**


-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
Paysage1 -> Practice
Landscape1->Practice
Paysage1 -> Ravageur
Landscape1->Pest
Paysage1 -> Adventic
Landscape1->Adventice
Paysage1 -> Costspec
Landscape1->SpecCost
Paysage1 -> Prodbrut
Landscape1->Grossprod
Paysage1 -> Margeuha
Landscape1->Marginuha
Paysage2 -> Practice
Landscape2->Practice
Paysage2 -> Ravageur
Landscape2->Pest
Paysage2 -> Adventic
Landscape2->Adventice
Paysage2 -> Costspec
Landscape2->SpecCost
Paysage2 -> Prodbrut
Landscape2->GrossProd
Paysage2 -> Margeuha
Landscape2->Marginuha
Practice -> Ravageur
Practice->Pest
Practice -> Adventic
Practice->Adventice
Practice -> Costspec
Practice->SpecCost
Practice -> Prodbrut
Practice->GrossProd
Practice -> Margeuha
Practice->Marginuha
Ravageur -> Costspec
Pest->SpecCost
Ravageur -> Prodbrut
Pest->Grossprod
Ravageur -> Margeuha
Pest->Marginuha
Adventic -> Costspec
Adventice->SpecCost
Adventic -> Prodbrut
Adventice->GrossProd
Adventic -> Margeuha
Adventice->Marginuha
Costspec -> Margeuha
SpecCost->Marginuha
Prodbrut -> Margeuha
GrossProd->Marginuha
Subsidys -> Margeuha
Subsidyst->Marginuha
Structural Model : effect distribution
direct
and
indirect
indirects
directs
Effets

Bibliographical References

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Vinzi, E.V., Chin, W.W., Henseler, J., Wang, H. (2010) *Handbook of Partial Least Squares : Concepts, Methods and Applications*, Springer, 798 p.