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

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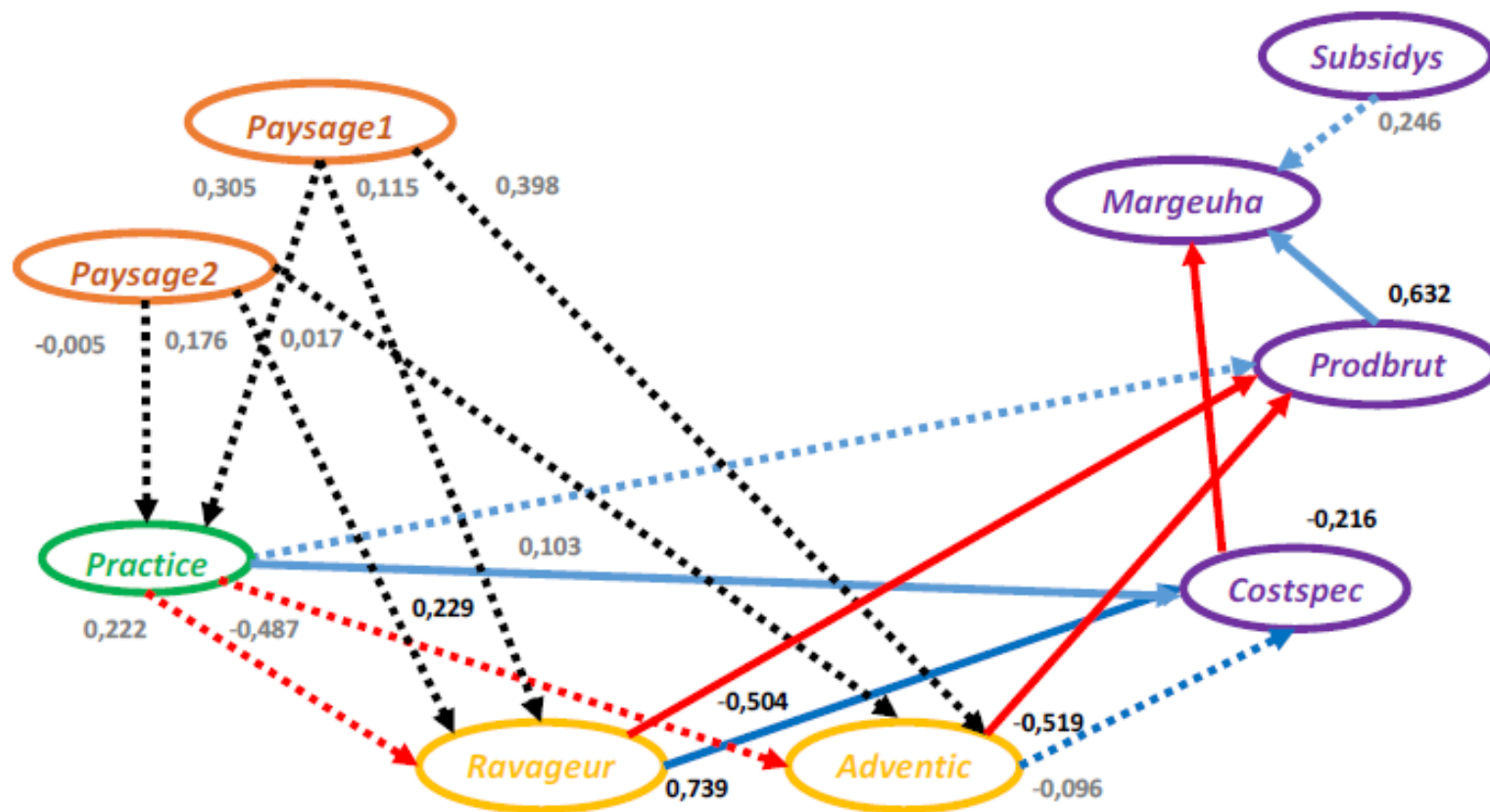
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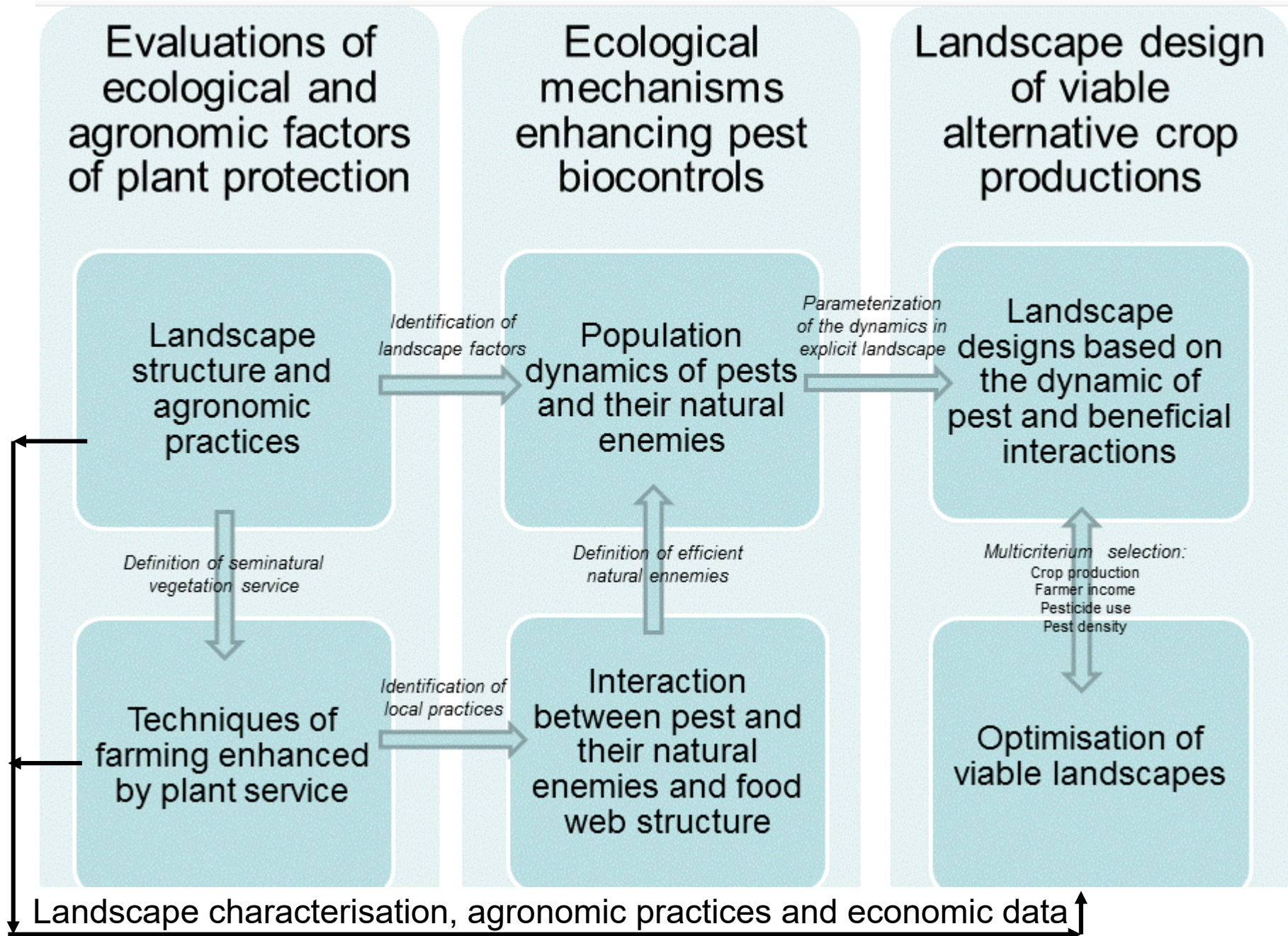
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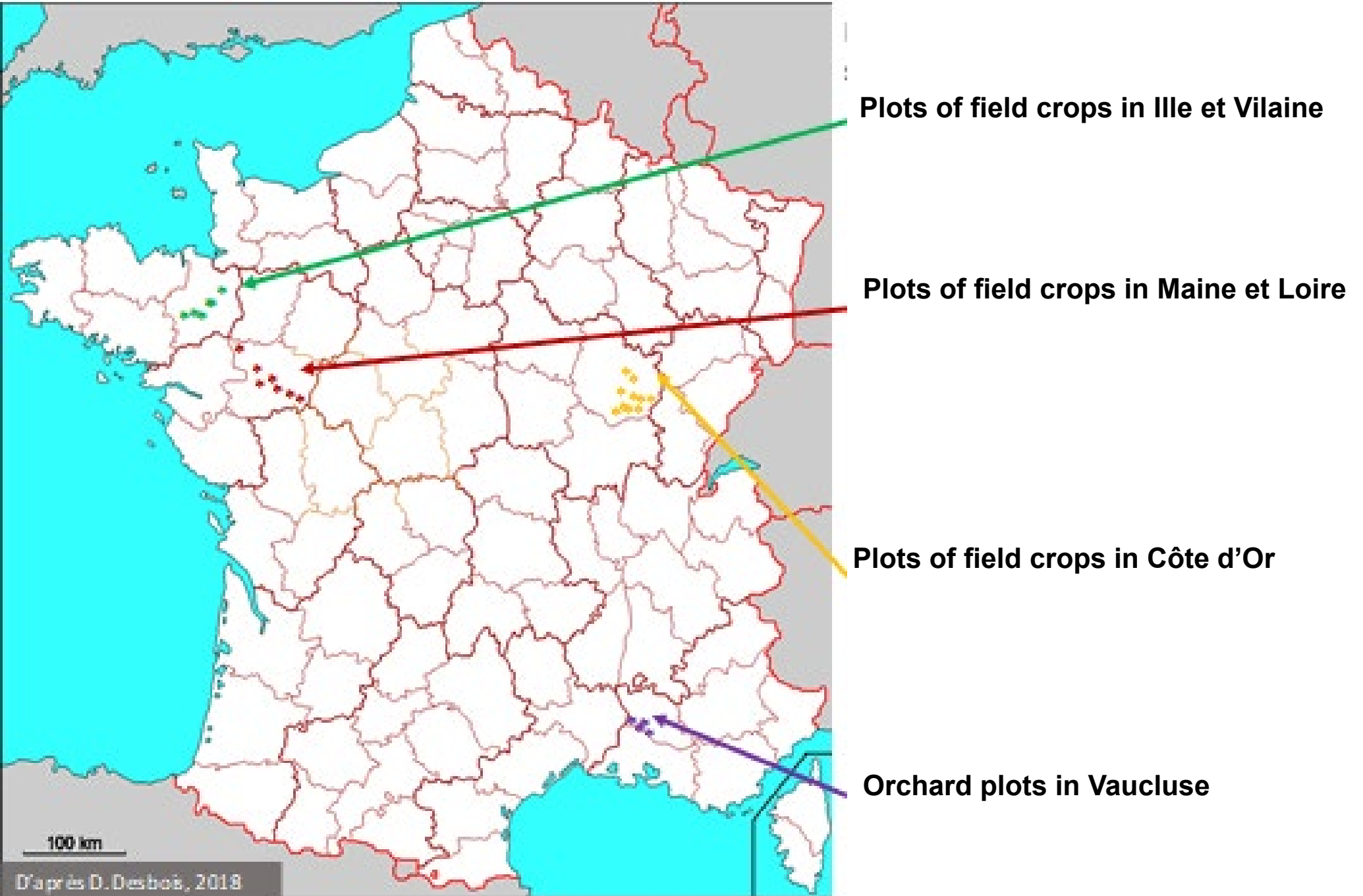
Dominique Desbois, UMR Économie publique,
INRAE-AgroParisTech



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



Peerless: location of agricultural plots



Peerless: type of variables (I)

Latent Variables	Manifest Variables	Data		
		ecological	agronomic	economic
<i>Landscape 1</i>	<i>landscape diversity indicators</i>			
	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)	√		
<i>Landscape 2</i>	<i>landscape diversity indicators</i>			
	Shannon index in field crops	√		
	Shannon index for all outputs	√		
<i>Practice</i>	<i>Agronomic practices</i>			
	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)		√	
<i>Pest</i>	<i>Pests</i>			
	Sitobion avenae (cereal aphid)	√		
	M.dirhodul (cereal and rose aphid)	√		
	Total of aphids	√		
	Lema larvae (cereal leaf beetle)	√		
	Locust damage (%)	√		

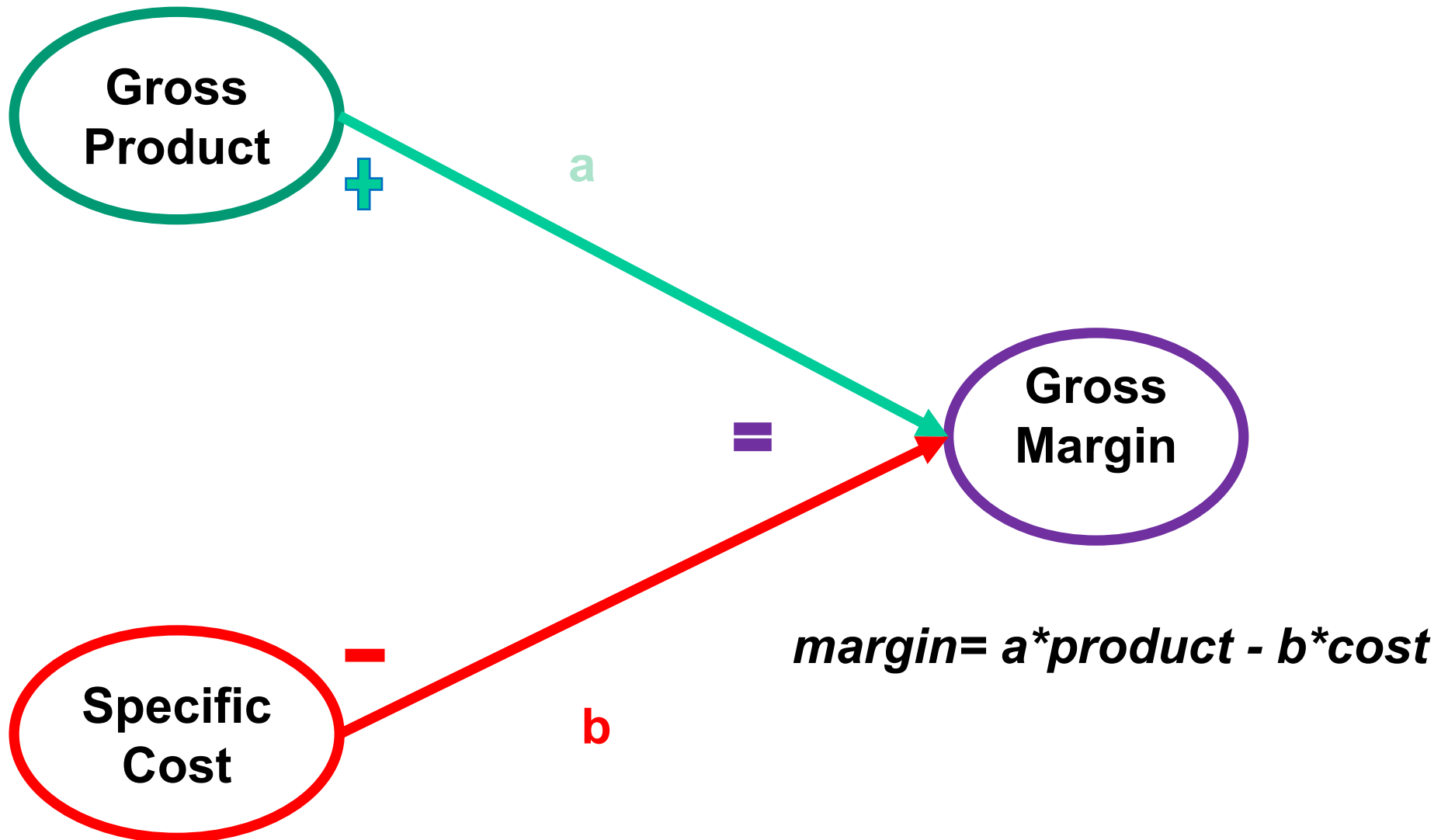
Peerless: type of variables (II)

Latent Variables	Manifest Variables	Data		
		ecological	agronomic	economic
<i>Adventice</i>	<i>Adventices</i>			
	Total weed cover (%)	√		
	Dicotyledons (%)	√		
	Grasses (%)	√		
	Number of species	√		
	Percentage of area under dicotyledons (%)	√		
	Percentage of area under grasses (%)	√		
<i>SpecCost</i>	<i>Specific Costs</i>			
	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)			√
<i>GrossProd</i>	<i>Gross Product</i>			
	Observed yields (t/ha)		√	√
	Price (€/t)			√
	Main output (€/ha)			√
	Total output (€/ha)			√
<i>Subsidys</i>	<i>Subsidies</i>			
	Single payment scheme (€/ha)			√
	Coupled aid (€/ha)			√
	Organic farming support (€/ha)			√
	Total aid (€/ha)			√
<i>Marginuha</i>	<i>Unit margin per hectare</i>			
	Gross margin per unit (€/ha)			√
	Gross margin including SFP (€/ha)			√
	Standard gross margin (€/ha)			√

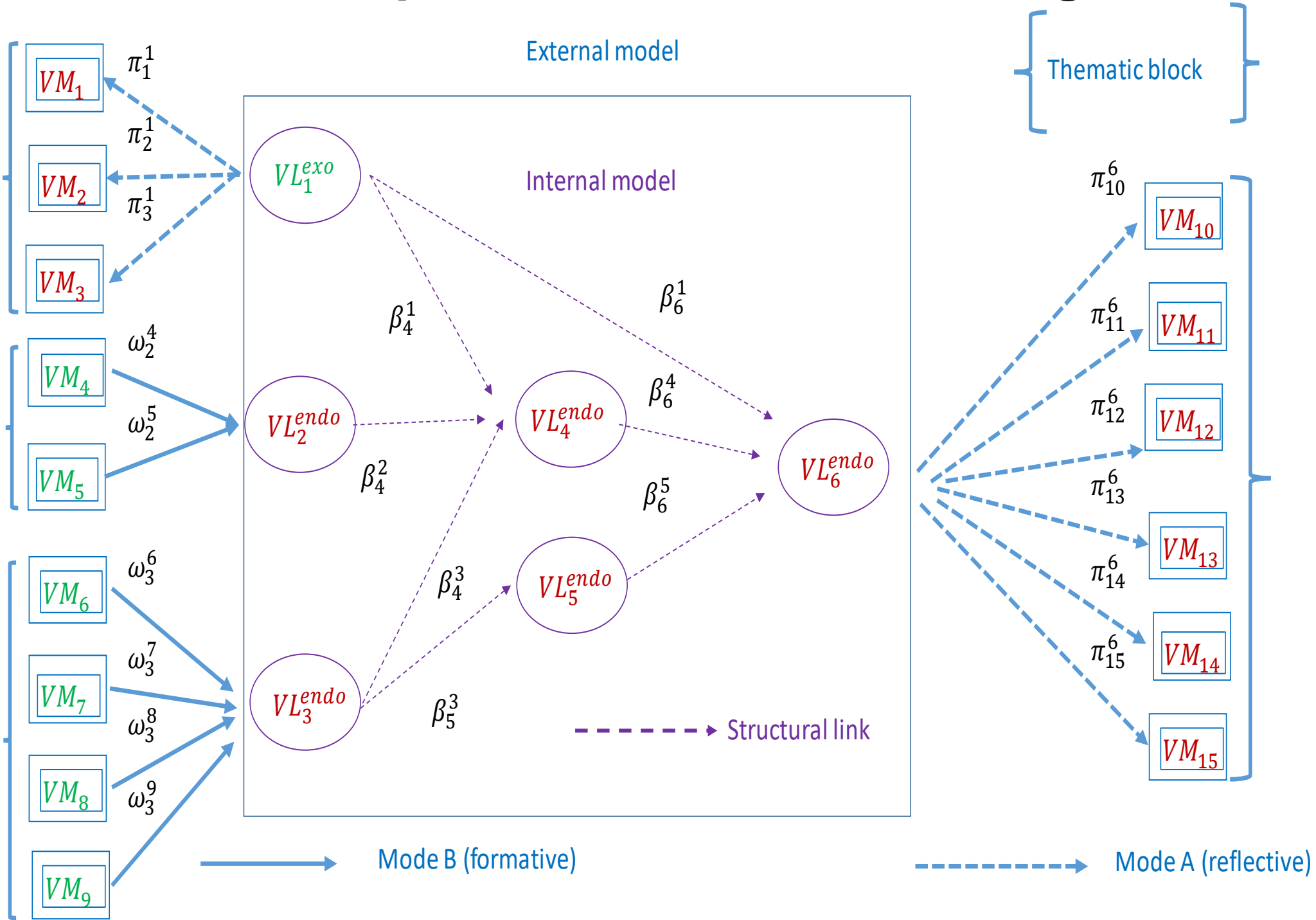
Structural model: the simplified example of the farm margin

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

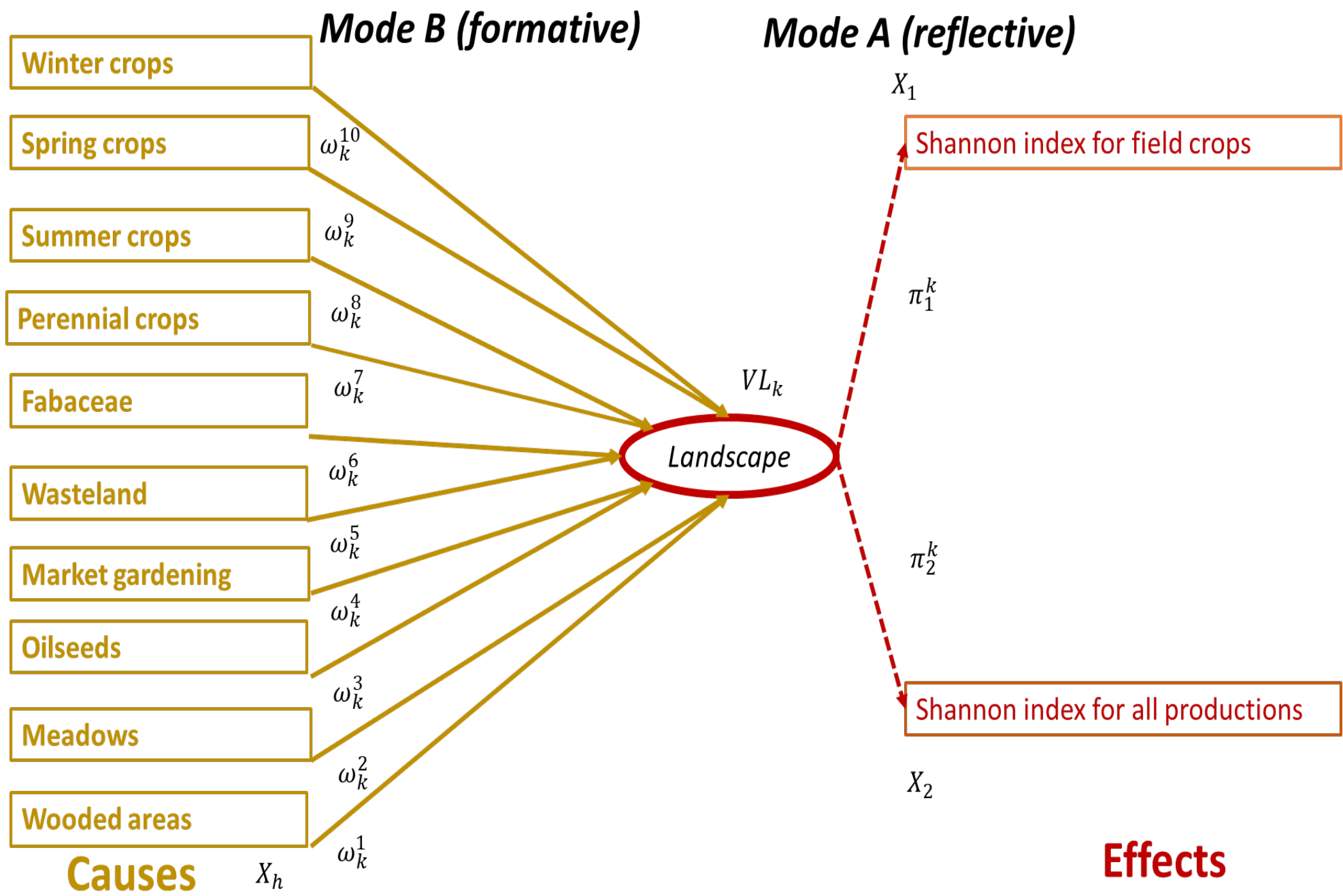
Let the structural equation be: $margin = f(product, cost)$



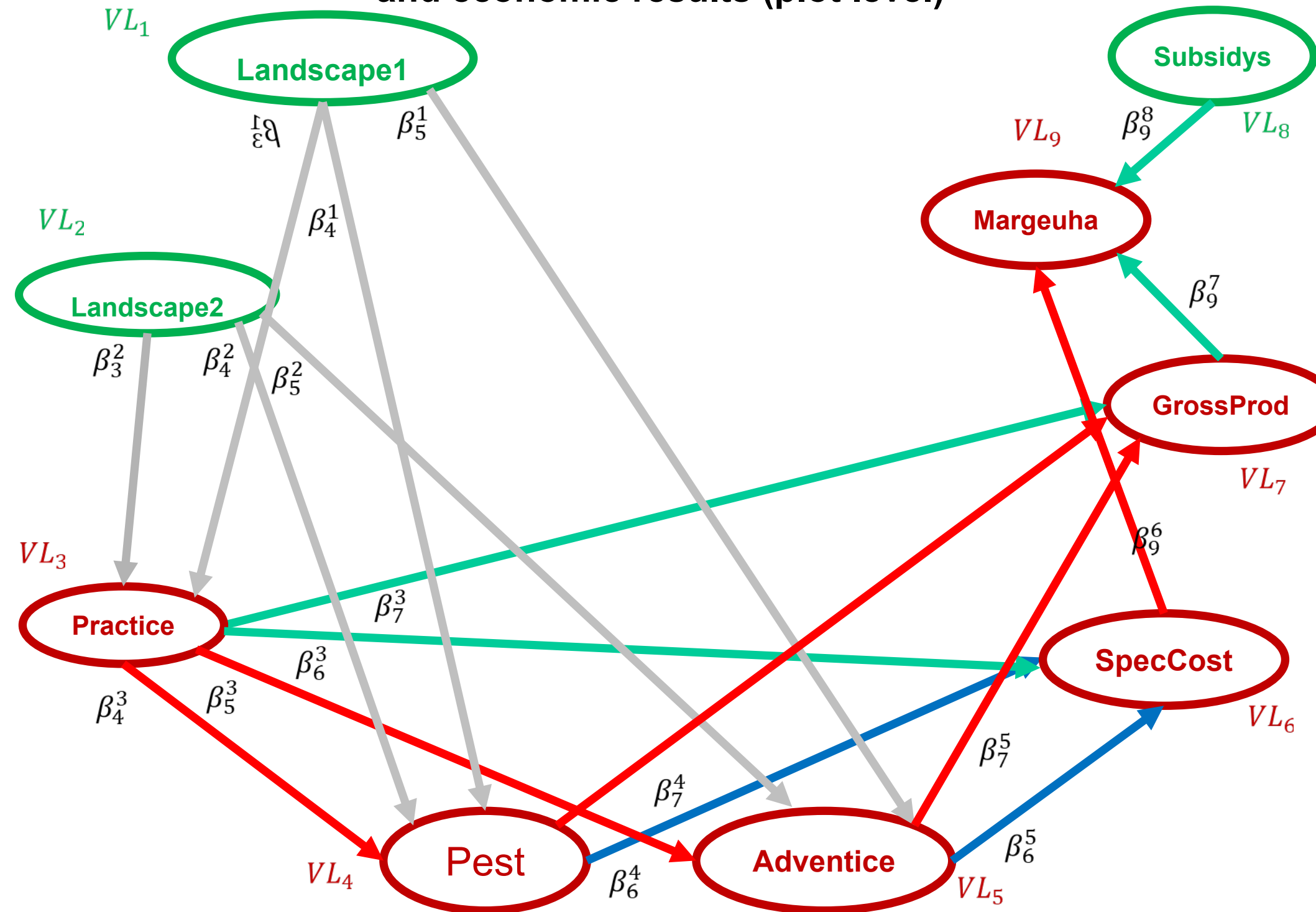
Concepts of structural modelling



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	<i>outer model</i>
## 2 \$inner_model	<i>inner model</i>
## 3 \$path_coefs	<i>path coefficients matrix</i>
## 4 \$scores	<i>latent variable scores</i>
## 5 \$crossloadings	<i>cross-loadings</i>
## 6 \$inner_summary	<i>summary inner model</i>
## 7 \$effects	<i>total effects</i>
## 8 \$unidim	<i>unidimensionality</i>
## 9 \$gof	<i>goodness-of-fit</i>
## 10 \$boot	<i>bootstrap results</i>
## 11 \$data	<i>data matrix</i>

R Source

<http://cran.r-project.org/web/packages/plspm/index.html>

Uni-dimensionnality Statistics : values of the initial coding

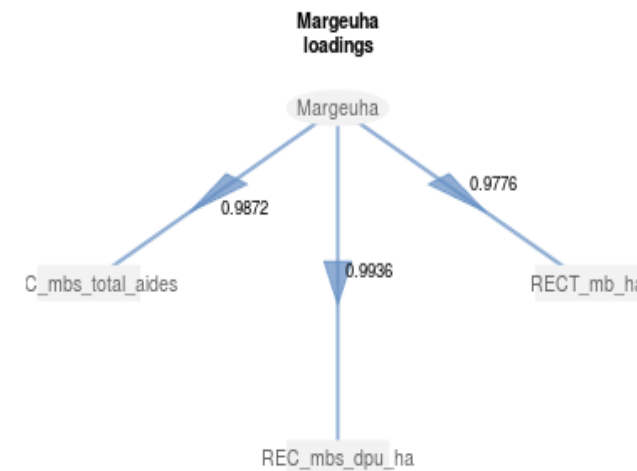
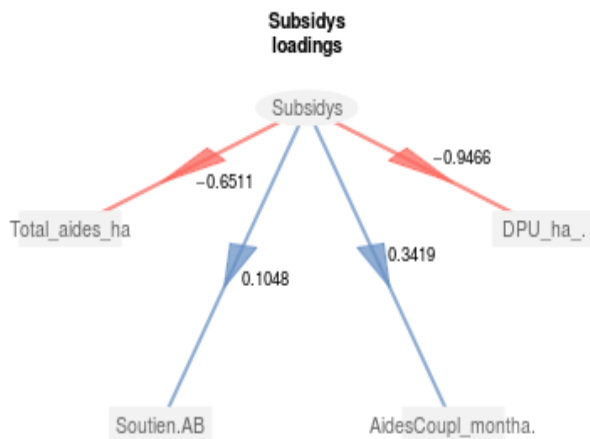
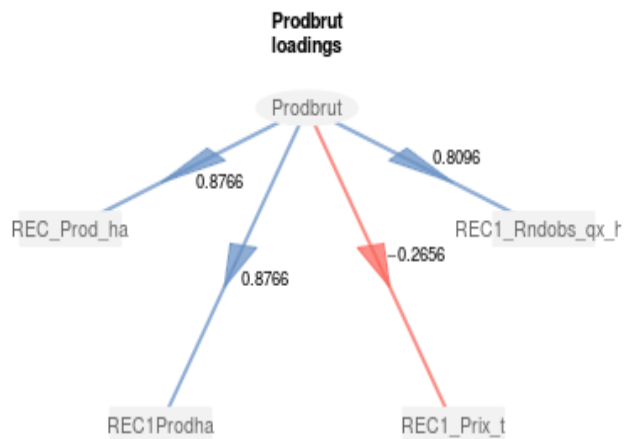
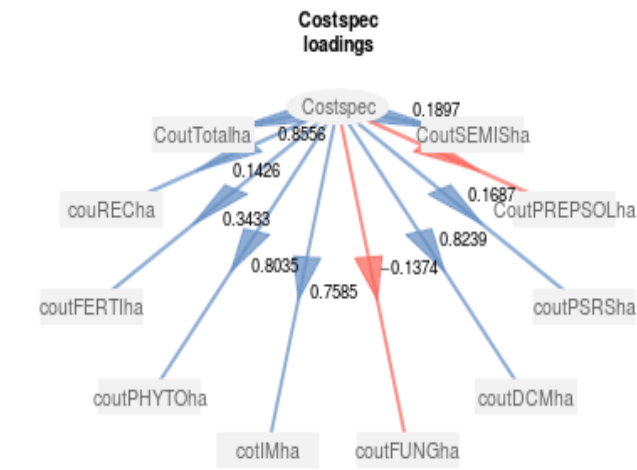
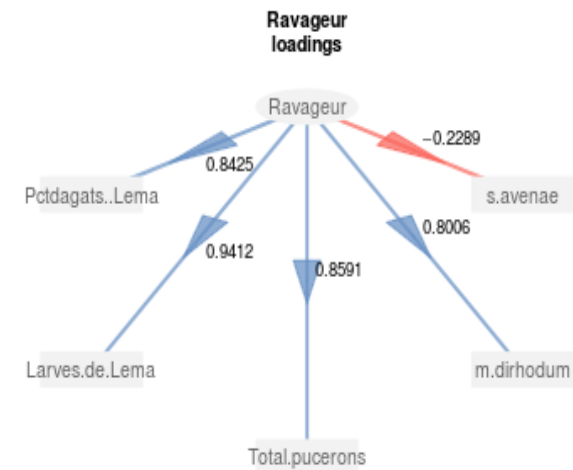
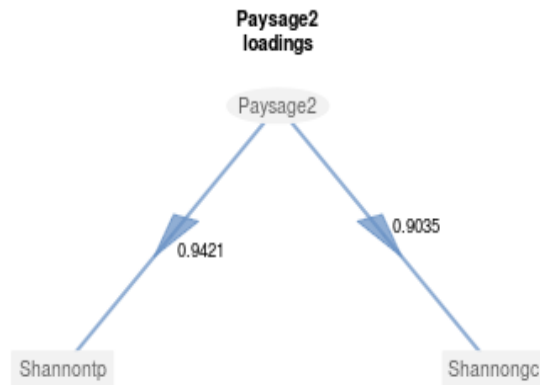
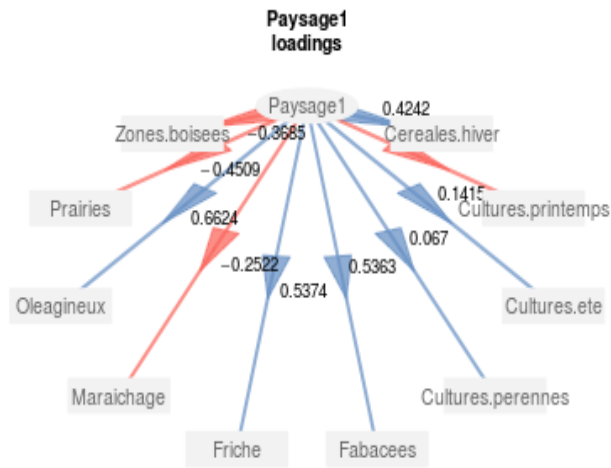
Blocks	Mode	Observed Var	Cronbach's Alpha	Dillon-Goldstein's Rho	Eigenvalue 1	Eigenvalue 2
Landscape1	A	9	0.398	0.073	2.04	1.67
Landscape2	A	10	0.473	0.642	1.84	1.45
Practice	A	18	0.943	0.950	9.45	3.20
Pest	A	5	0.807	0.874	3.03	0.96
Adventice	A	6	0.871	0.904	3.68	1.09
SpecCost	A	10	0.834	0.879	4.75	2.30
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



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**.

Goddness of Fit : communalities, R² and redundancies

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

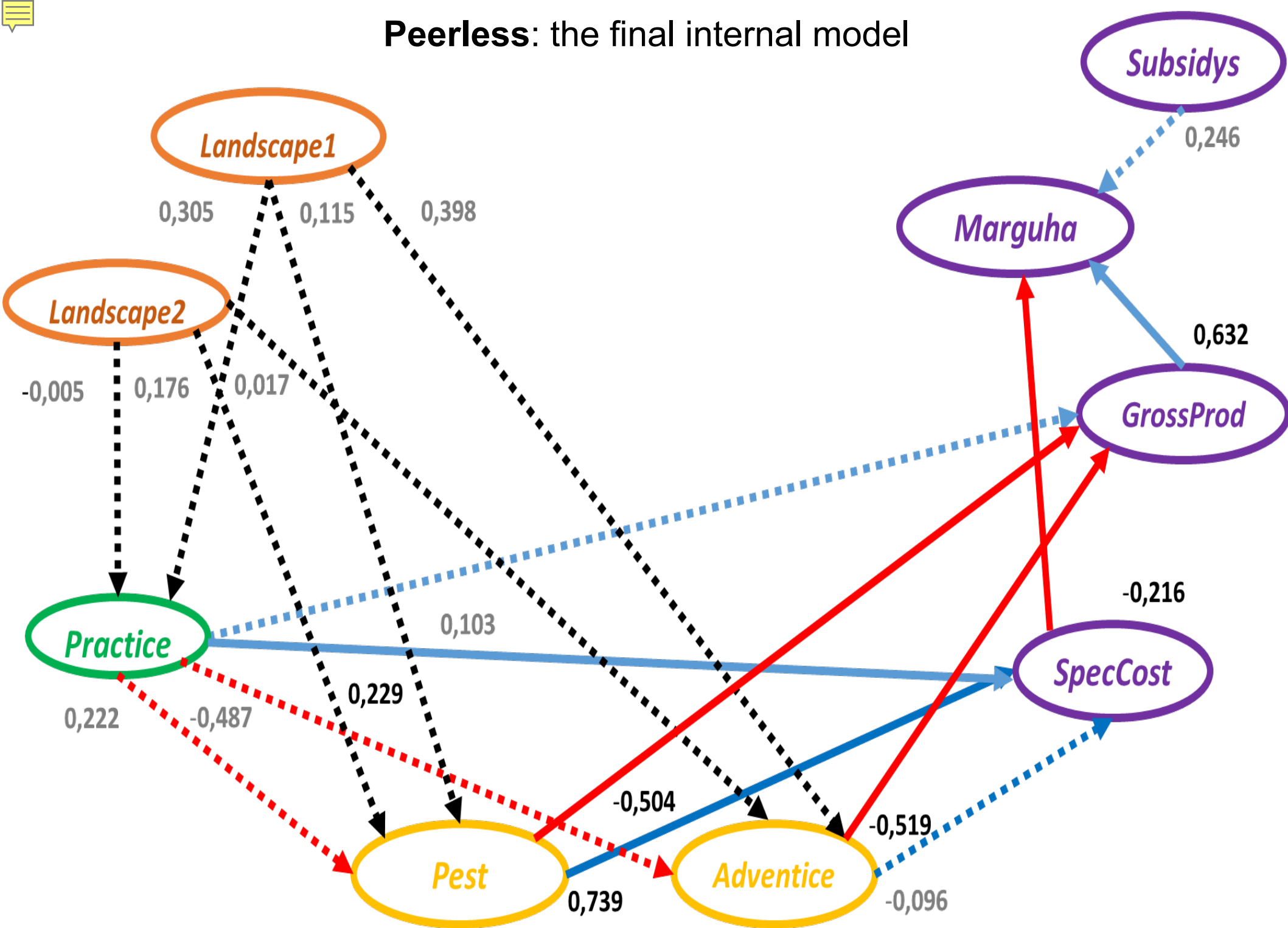
The **GoF value**, the overall indicator of the goodness of fit of the amended model, improves quite marginally, reaching **0.5078** .

Structural Links of the Model: bootstrap estimates

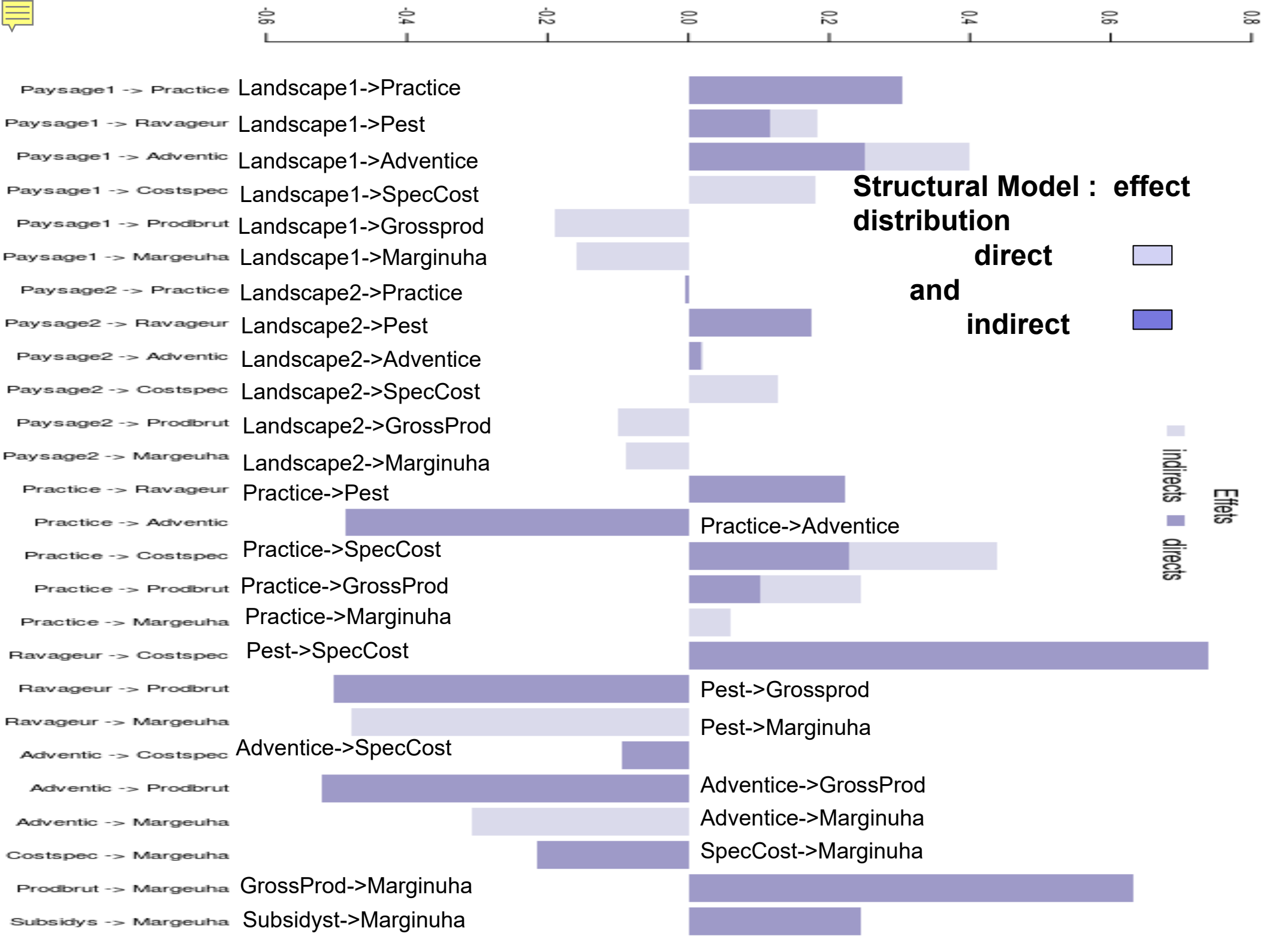
Link	Estimate	Bootstrap Estimate	Standard-error	Q(0.025)	Q(0.975)
Landscape1 -> Practice	0.305	0.249	0.323	-0.521	0.639
Landscape1 -> Pest	0.115	0.203	0.251	-0.380	0.552
Landscape1 -> Adventice	0.398	0.431	0.215	-0.227	0.692
Landscape2 -> Practice	-0.005	-0.045	0.188	-0.365	0.297
Landscape2 -> Pest	0.176	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**





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