

Using gaussian process metamodels for sensitivity analysis of an individual-based model of a pig fattening unit



A. CADERO ^(1,2), A. AUBRY ⁽¹⁾, L. BROSSARD ⁽²⁾, F. BRUN ⁽³⁾, J.Y. DOURMAD ⁽²⁾, Y. SALAUN ⁽¹⁾ AND F. GARCIA-LAUNAY ⁽²⁾

¹ IFIP – Institut du porc, 35651, Le Rheu, France; ² PEGASE, INRA, Agrocampus Ouest, 35590, Saint-Gilles, France; ³ ACTA – Les Instituts Techniques Agricoles, 31326, Castanet-Tolosan, France; Corresponding author : alice.cadero@inra.fr

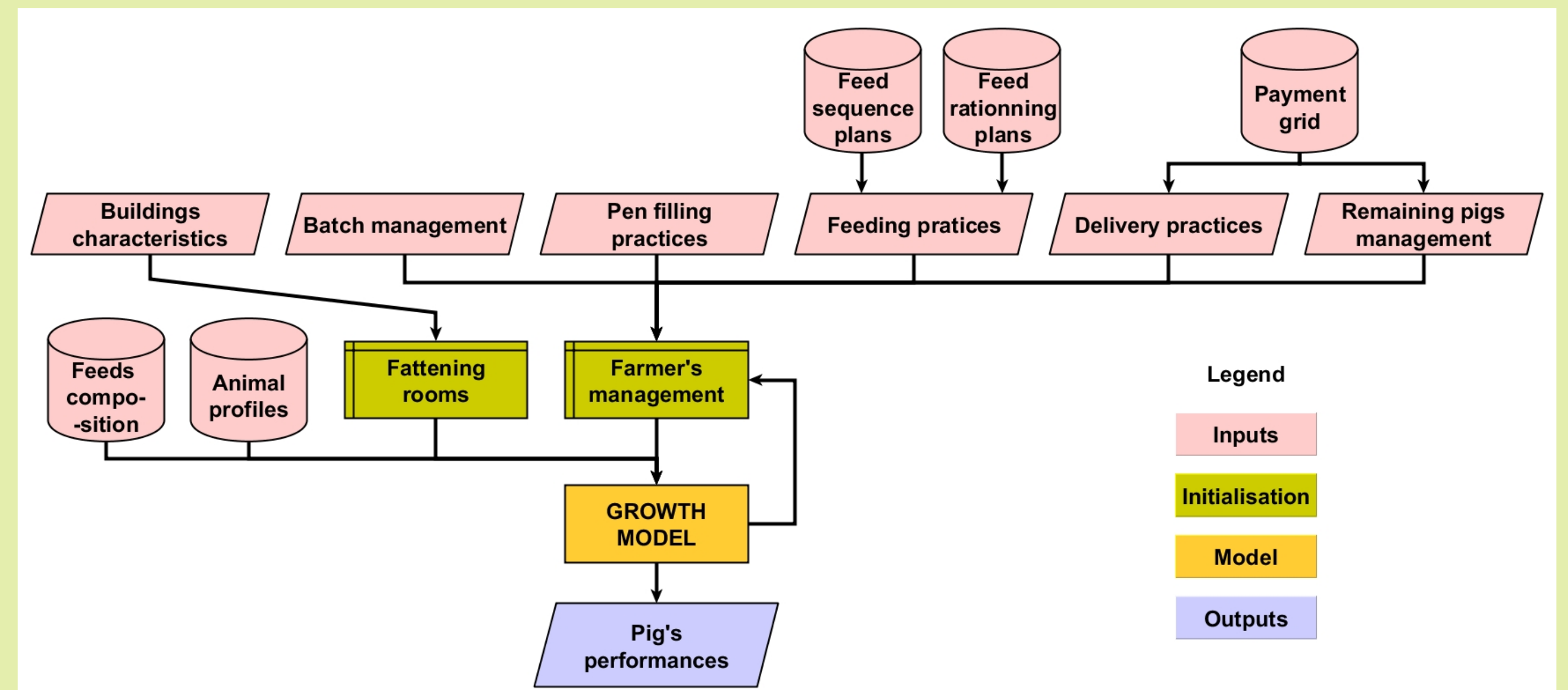
Objective

To define and implement an appropriate sensitivity analysis approach for an individual-based model

Model description

a pig fattening unit model able to

- Simulate individual performance of pigs (variability) X with farmer's practices
- Evaluate the effects of these practices on technical, economic and environmental performance.
 - Dynamic (daily time step)
 - Stochastic (animal profiles, mortality)
 - Mechanistic
 - Discrete-event model (agenda of events)
 - ~10 min per simulation



Sensitivity analysis

- 14 inputs tested (5 integers, 9 real numbers)
- 10 outputs studied (technical and environmental results)

Two steps approach (due to calculation time)

- One gaussian process metamodel per output** (using 100 simulations)
- Extended Fourier Amplitude Sensitivity Test (**eFAST**) method (N = 1500 scenarios for each trajectory: 21000 simulations per metamodel)
 - ~200 time faster using gaussian process metamodels than using our model itself (2 h vs. 2.5 weeks of calculation)

Fig. A: Coefficients of variation of the model's studied outputs (using the 100 simulations for the metamodels)

- Variations of phosphorus excretion: 85% due to phosphorus intake
- Variations of nitrogen excretion: 84% due to nitrogen intake
- Variations of percentage of pigs in optimal slaughter weight range: 38% due to cleaning period, 18% due to minimum number of pigs per delivery to slaughterhouse, 14% due to quantity of feed intake, 8% due to the number of places per pen

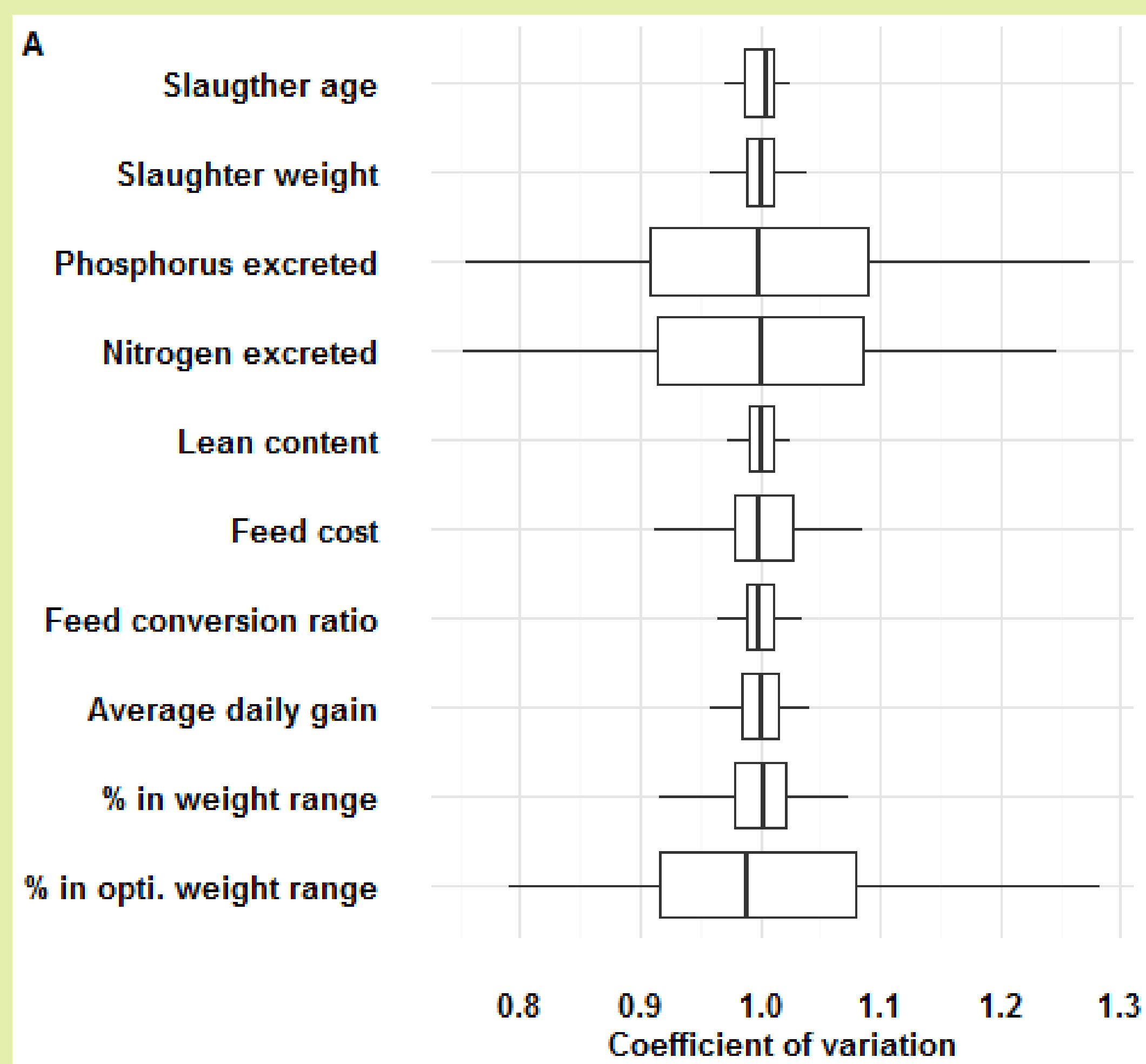
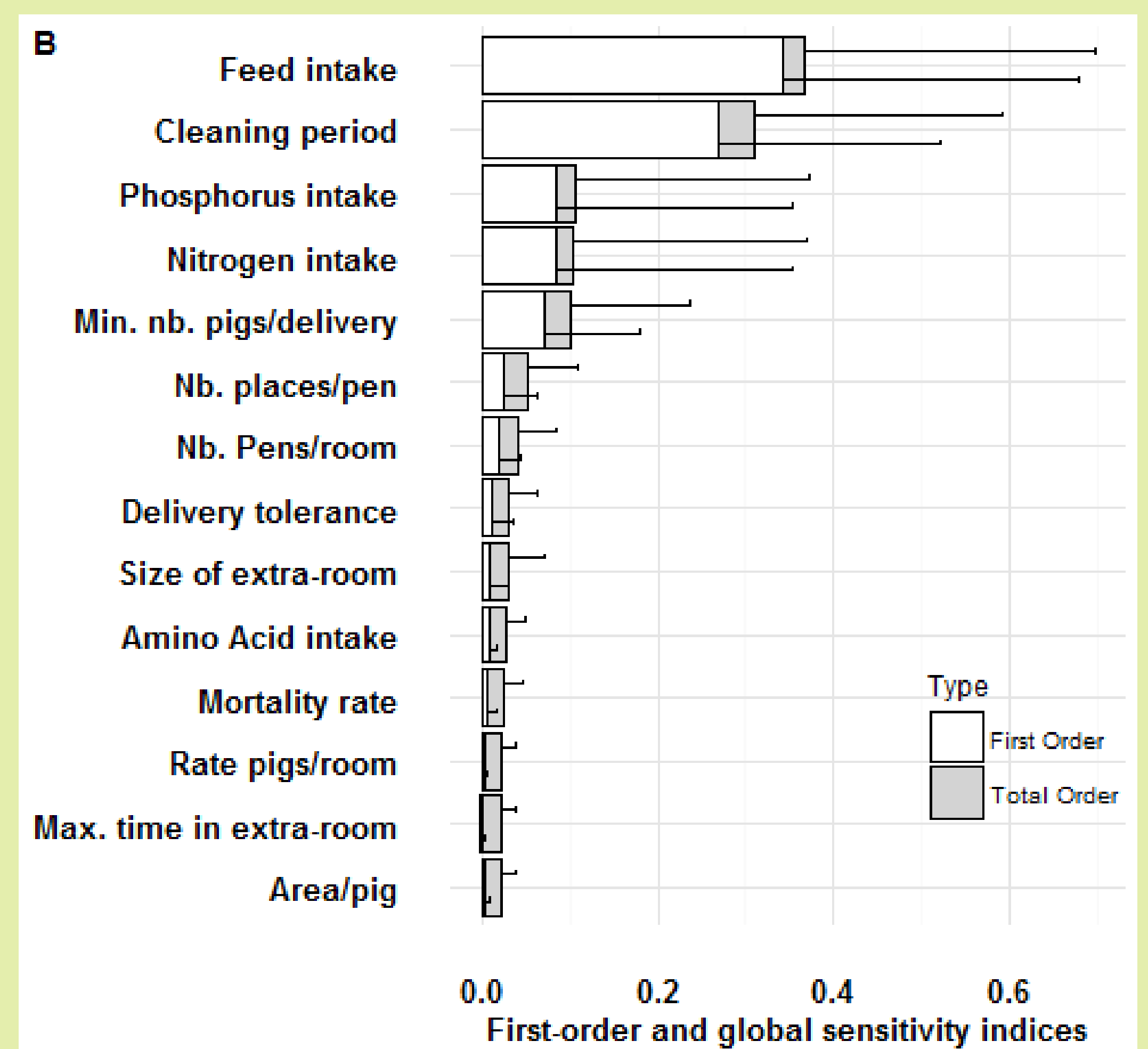


Fig. B: Average sensitivity indices of the inputs investigated, among all the outputs

- Feed intake explains 37 % of the variation
- Duration of cleaning period explains 31 % of the variation
- Phosphorus and Nitrogen intake explain each 11 % of the variation
- Minimum number of pigs per delivery explains 10 % of the variation
- The other inputs explain each less than 5 % of the variation



Conclusion

The sensitivity analysis allowed us to

- Validate the **model behaviour** by expertise
- Identify the most sensitive inputs (>30% of sensitivity explained, feed intake, cleaning period) and the less sensitive inputs which can be set for routine use (<5% of sensitivity explained, number of places per pen, number of pen per room, delivery tolerance, size of extra-room, amino acid intake, mortality rate, rate of pigs per room, maximum time fatten in extra-room, area allocated per pig)

→ Perspective: These results will be confirmed by a second sensitivity analysis including newly implemented economic and environmental (calculated by Life Cycle Assessment) results.