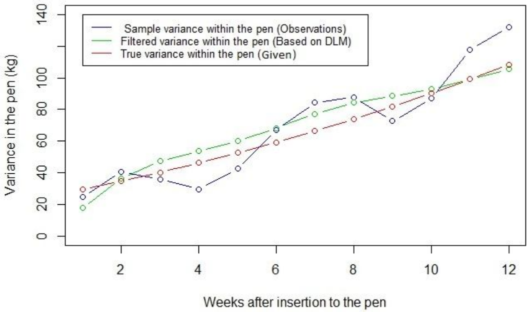
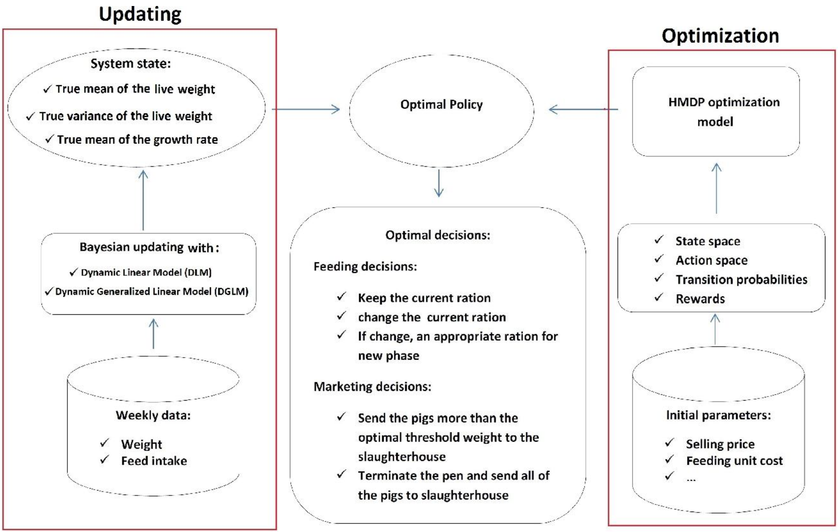
Updating model - Validating the DGLM

- To validate the DGLM model, the observations were generated by a simulation approach and we supposed the true variances within the pen are given in this step.
- The inhomogeneity of the pen can be represented well by the suggested DGLM model.
- We have a good prediction for the true variance of the pen in each week by the suggested DGLM model.



Modelling approach - framework



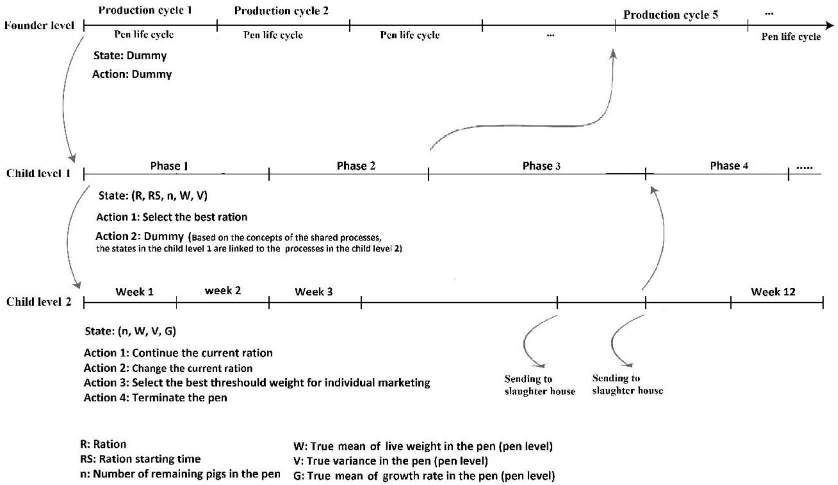
Modelling approach - Optimization model

A three-level Hierarchical Markov Decision Process (HMDP) is used which is a Markov Decision Process (MDP) where each stage is itself a MDP (Kristensen and Jørgensen, 2000).

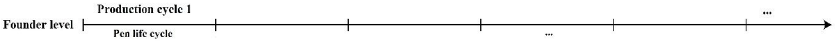
Why did we select HMDP for the optimisation part?

- HMDP is a solution for the curse of dimensionality problem. By using this approach, the total number of states will be less in comparison with the traditional MDPs.
- Hierarchical levels will cause to a decrease in the number of linear equations required for the policy iteration method and hence large models can be solved fast.
- HMDP has a good structure for modelling the hierarchical decisions.

Three-level HMDP

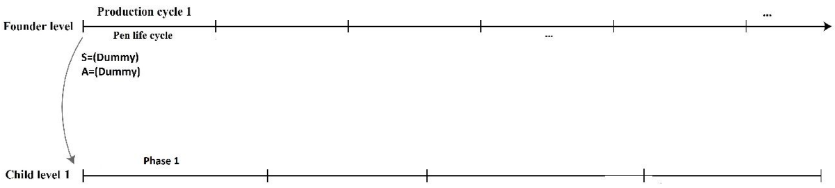


Modelling approach - HMDP[1] structure



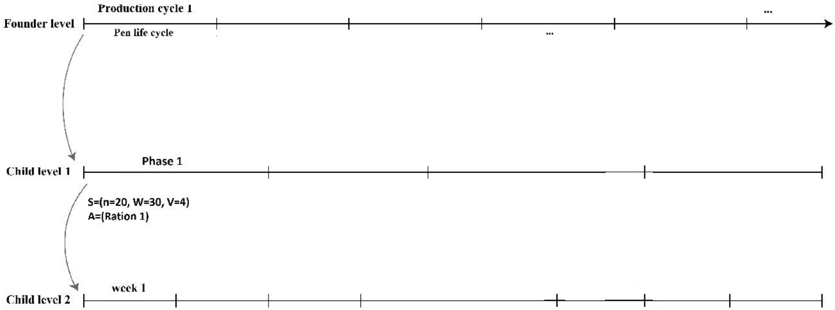
[1] Hierarchical Markov Decision Process

Modelling approach - HMDP[1] structure



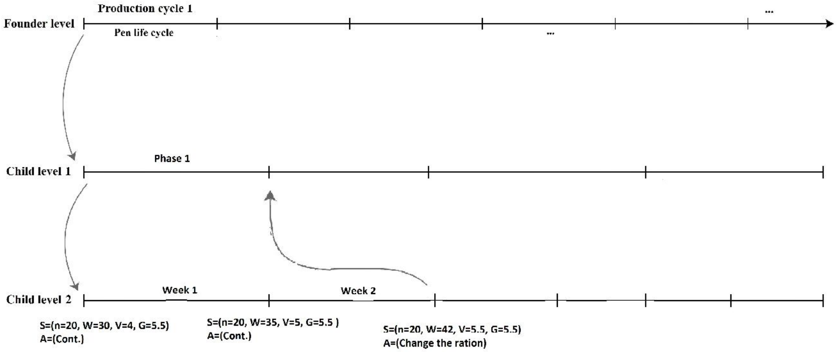
[1] Hierarchical Markov Decision Process

Modelling approach - HMDP[1] structure



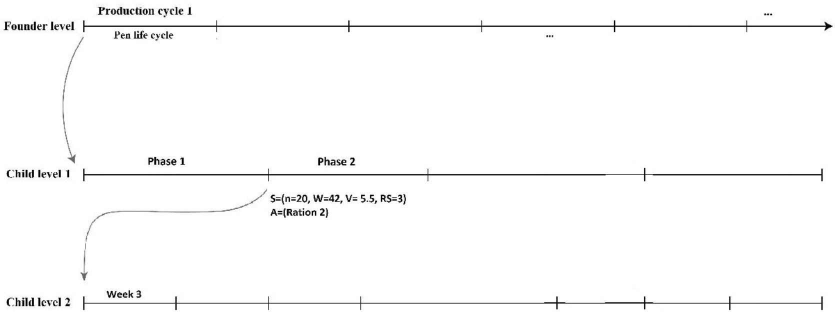
[1] Hierarchical Markov Decision Process

Modelling approach - HMDP[1] structure



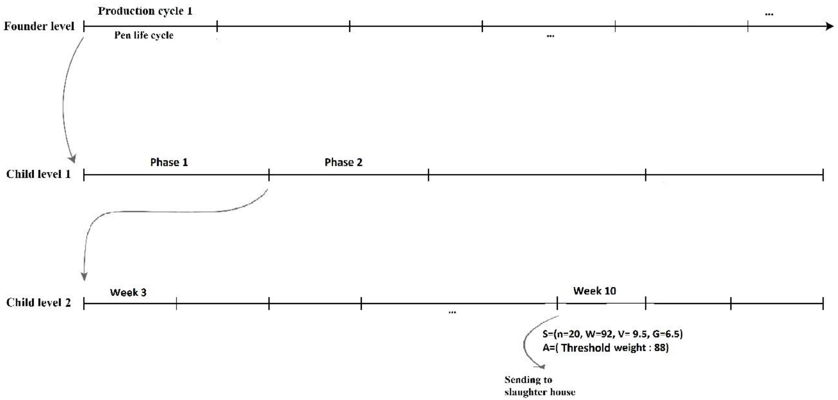
[1] Hierarchical Markov Decision Process

Modelling approach - HMDP[1] structure



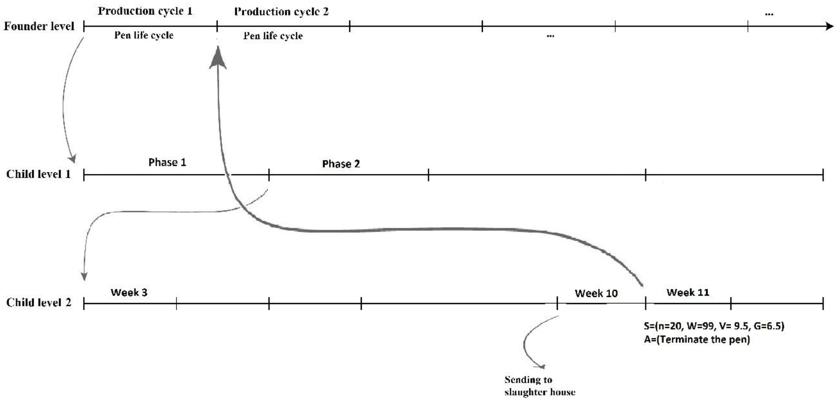
[1] Hierarchical Markov Decision Process

Modelling approach - HMDP[1] structure



[1] Hierarchical Markov Decision Process

Modelling approach - HMDP[1] structure



Optimization Model- Transition probabilities

- We suppose jump probabilities between the levels are given in the assumptions of the problem.
- Transition probabilities in the last level (child level 2) are calculated based on the properties of the suggested DLM and DGLM models to acquire the true information in the pen:

$S_t = (n_t, [W_t, G_t], V_t)$

n_t: number of remaining pigs, $[W_t, G_t]$: the vector of true means of live weight and growth rate, V_t: true variance of live weight

$$P_{A_t}(S_{t+1}|S_t) = P_{A_t}(n_{t+1}|n_t) * P_{A_t}(W_{t+1}, G_{t+1}|W_t, G_t) * P_{A_t}(V_{t+1}|V_t)$$

$(n_{t+1}|n_t)$: Binomial

$(W_{t+1}, G_{t+1}|W_t, G_t)$: Bivariate normal distribution

$(V_{t+1}|V_t)$: Inverse - gamma distribution

Optimization Model- Reward function

- Reward functions in the first and the second levels (founder process and child level 1) are depended to the reward function in the last level of HMDP.
- Reward function in the last level is computed according to the revenue of selling the pigs to the slaughterhouse, cost of feeding the pigs and cost of buying the new piglets:

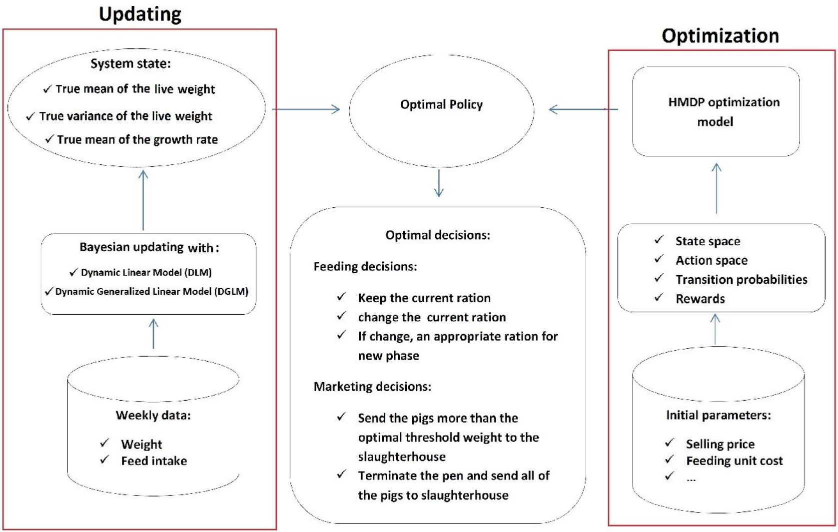
$$C_t(S_t, A_t) = I_{(A_t=M,T)} p_s * ns_t * R_t(W_t, V_t) + I_{(A_t=M,T)} p_l * ns_t * L_t(W_t, G_t, V_t)$$
$$-I_{(A_t=M,K)} c_f * nk_t * F_t(W_t, G_t) - I_{(A_t=T)} c_b * n$$

- $R_t(W_t, V_t)$: A random function to calculate the average carcass weight in the pen
- $F_t(W_t, G_t)$: A random function to calculate the average feed intake in the pen
- $L_t(W_t, G_t, V_t)$: A random function to calculate the leanness contribution of the meat
- p_s : Unit price of 1 kg carcass
- p_1 : Bonus for 1 percent increase in the leanness
- c_f : Unit cost of 1 FU_p for ration f
- c_b : Unit cost of buying one new piglet
- ns_t : Number of pigs sold to the slaughter house
- nk_t : Number of pigs kept in the pen
- I : Index function for the possible actions - K: Keep, M: Individual Marketing, T: Terminate.

Optimization Model- Solution procedure

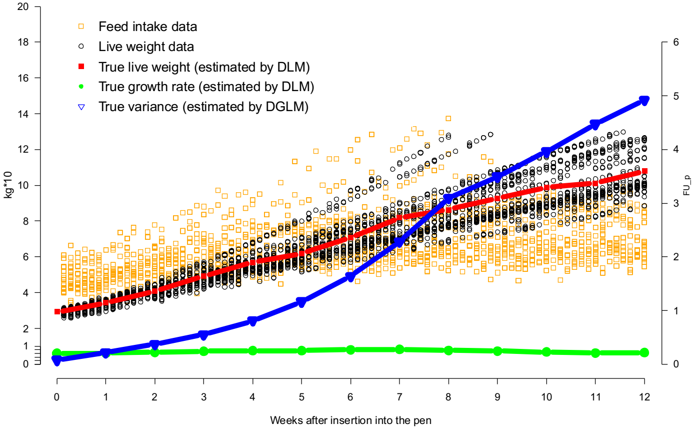
- Three-level HMDP is solved by combination of policy and value iteration methods:
  - Policy iteration method is used for the infinite MDP in the founder process;
  - Value iteration method is applied for the finite MDPs in the child levels 1 and 2 million states and 5 million actions.
- The model of the three-level HMDP was built in the C++ programming language.
- The three-level HMDP was solved by the package ”MDP” (Nielsen, 2009) with about 2 million states and 5 million actions.

Modelling approach - framework

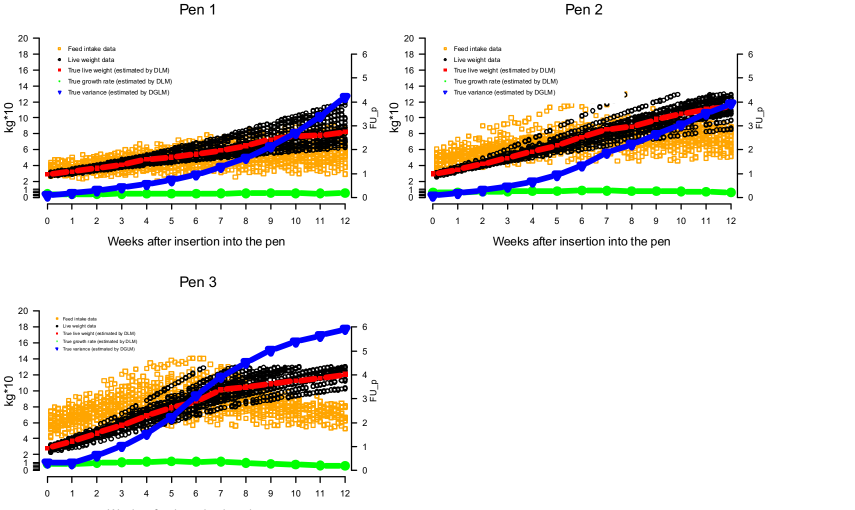


Results - Updating part (DLM and DGLM models)

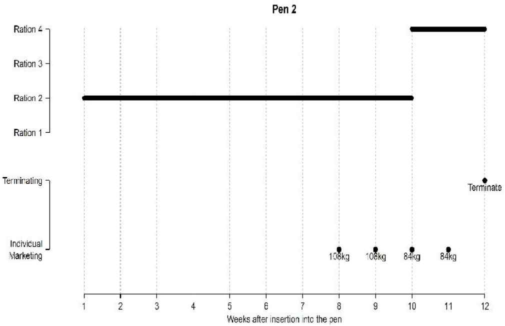
To show the efficiency of the proposed optimisation model, we implemented our model in the three pens with different genetic properties in the growth rate.



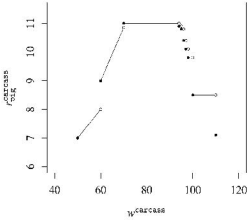
Results - Updating part (DLM and DGLM models)



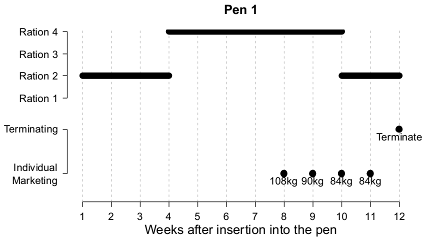
Results - Optimization part (HMDP model)

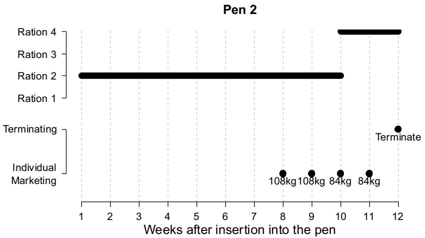


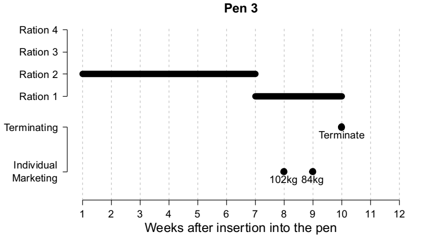
Ration	Average growth rate (kg)	Unit cost (DKK/FEsv)
1	4	1.8
2	4.8	1.9
3	5.6	2
4	6.4	2.1



Results - Optimization part (HMDP model)

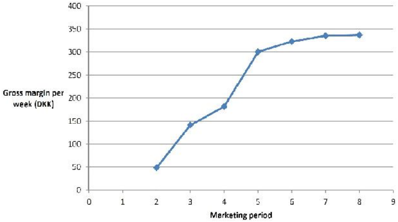






Results - Optimization part (HMDP model)

Scenario Name	Changed parameter	Gross margin Per week
Basic	-	181.756
Group 1	$T = 10$	48.87
	$T = 11$	141.351
	$T = 13$	300.317
	$T = 14$	332.928
	$T = 15$	335.916
	$T = 16$	337.268
Group 2	20% increase in the unit cost of rations	110.13
	20% decrease in the unit cost of rations	255.071



Agenda

PigIT research group

Optimal feeding and marketing decisions

- Problem definition
- Modelling approach
- Initial results

Further research

Further research

- Solving the problem in the herd level with at least 200 animals
- Using Approximate Dynamic Programming (ADP) approach to solve the problem in this size.
- Considering the mortality of the pigs and also the diseases problems in the model.

Questions