**Supplementary material: Appendices**

Appendix A.1: Sample of a choice set

*Instruction*: Imagine that an advisor has suggested the following alternative feed rations. You can only choose from the suggested options. Evaluate the rations carefully based on their characteristics and choose one of them for your dairy farm. If you would not choose feed ration A and B if you were faced with a real choice, you can choose feed ration C, which is your current feed ration. Note that the feed rations are not necessarily available to use in a real-world situation and some may seem counterintuitive to you. This is not a mistake, but part of the study design. Simply choose the feed ration you prefer most from the options you are faced with.

Which of the following feed rations would you choose?

|  |  |  |  |
| --- | --- | --- | --- |
|  | Feed ration A | Feed ration B | Feed ration C |
| GHG emissions | -10% reduction | 0% (Unchanged) | Neither A nor B.  I would  maintain my current feed ration |
| Animal welfare | High improvement | Low improvement |
| Milk yield | 0% (Unchanged) | -10% reduction |
| Biodiversity | No improvement | High improvement |
| Feed self-sufficiency | 0% (Unchanged) | +20% increase |
| Feed cost | -20% reduction | 0% (Unchanged) |

I would choose: feed ration A [ ] feed ration B [ ] feed ration C [ ]

Appendix A.2: Methodological framing of hybrid choice model

The latent variable model adopts the structural equation modelling setup with a simultaneous estimation of measurement and structural components of the model (Anderson and Gerbing, 1988; Diamantopoulos et al., 2008). The measurement component tests how the latent environmental, social and economic identities relate to their indicators. Thus, we specify the scores on the identity indicators as effects of the scores on their underlying latent constructs:

Where: is the score for dairy farmer (on reflective indicator (of the latent identity construct ( are the factor loadings, reflecting the effect of on . is the measurement error associated with a given score, which is assumed to be and uncorrelated across indicators[[1]](#footnote-1). The structural component tests the relationships between observable dairy farmer characteristics and the identity constructs:

Where: is the coefficient, reflecting the effects of the observable farmer characteristic on . The error term is assumed to be normally and allowed to correlate across the latent identity constructs. The factor scores on the latent identity constructs are incorporated into the MXL model as interaction with treatment and attributes:

Where: is a vector of parameter estimates of interest that capture the heterogeneous effects of the treatment by farmer identities, i.e., how the effects of the treatment vary with differences in different farmer identities: environmental and social identities.

In the case of treatment effect heterogeneity by farmer prior knowledge of grass-based feeding systems (, where a hybrid choice model is not required, the model parameterization is as follows:

Where: is a vector of parameter estimates of interest that capture the heterogeneous effects of the treatment by farmer prior knowledge of grass-based feeding systems through agricultural education and participation in grass-related feed training.

Appendix A.3: Supplementary tables

**Table A1**: Descriptive statistics of the indicators of farmers’ environmental, economic and social identities by treatment1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Label | Indicators | Full | Treatment | Control | *p-val2* |
| *Environmental identity* | | | | | |
| Idt\_env1 | To engage in environmentally friendly production practices is an important part of who I am. | 3.39 (0.05) | 3.46 (0.07) | 3.33 (0.07) | 0.232 |
|  |  |  |  |  |
| Idt\_env2 | I am not the type of person who thinks a lot about engaging in environmentally friendly production practices. | 3.51  (0.05) | 3.52  (0.08) | 3.50  (0.08) | 0.859 |
|  |  |  |  |  |
| Idt\_env3 | I would feel at a loss if I were forced to give up environmentally friendly production practices. | 3.02  (0.06) | 3.00  (0.08) | 3.03 (0.08) | 0.789 |
|  |  |  |  |  |
| *Social identity* | | | | | |
| Idt\_soc1 | To engage in production practices that can improve public acceptance of products is an important part of who I am. | 3.52  (0.05) | 3.48  (0.07) | 3.56 (0.06) | 0.389 |
| Idt\_sco2 | I am not the type of person who thinks a lot about engaging in production practices that can improve public acceptance of products. | 3.44  (0.05) | 3.39  (0.07) | 3.48 (0.07) | 0.374 |
|  |  |  |  |  |
| Idt\_sco3 | I would feel at a loss if I were forced to give up production practices that can improve public acceptance of products. | 3.43  (0.05) | 3.35  (0.08) | 3.51 (0.06) | 0.096 |
|  |  |  |  |  |
| *Economic identity* | | | | | |
| Idt\_eco1 | To engage in profit-maximizing production practices is an important part of who I am. | 3.87  (0.05) | 3.99  (0.07) | 3.77 (0.06) | 0.018 |
|  |  |  |  |  |
| Idt\_eco2 | I am not the type of person who thinks a lot about engaging in profit-maximizing production practices. | 3.66  (0.06) | 3.69  (0.08) | 3.63 (0.08) | 0.635 |
|  |  |  |  |  |
| Idt\_eco3 | I would feel at a loss if I were forced to give up profit-maximizing production practices. | 3.45  (0.05) | 3.51  (0.07) | 3.56  (0.07) | 0.619 |
|  |  |  |  |  |
| Observations |  | 375 | 176 | 199 |  |

*Notes*: *1*Elicited based on level of agreement or disagreement to different environmental, economic and social identity statement on a scale of 1 to 5 (1=strongly disagree to 5=strongly agree). *2p-*values fromtests of equality of means between treatment and control groups using two-sided t-test. Values in parentheses are standard deviations. We reverse coded Idt\_env2, Idt\_eco2 and Idt\_soc2 in the analysis such that agreement with these indicators suggests a pro-environmental identity, a pro-economic identity, and a pro-social identity, respectively.

**Table A2:** Comparison of the study sample and the target population

|  |  |  |
| --- | --- | --- |
|  | Sample | Population |
| *Farm size (hectares)* |  |  |
| 0-10 | 1.07% | 1.08% |
| 10.1-20 | 1.87% | 1.51% |
| 20.1-30 | 2.67% | 3.07% |
| 30.1-50 | 8.80% | 10.46% |
| 50.1-100 | 26.67% | 27.24% |
| > 100 | 58.93% | 56.64% |
| = 1.64 (*p*-value = 0.896) | | |
| *Annual agricultural labor time (hours)* | | |
| 800.0-1599.9 | 0.27% | 0.26% |
| 1600.0-2399.9 | 3.47% | 3.03% |
| 2400.0-3199.9 | 8.80% | 10.20% |
| 3200.0-3999.9 | 13.33% | 14.74% |
| 4000.0-5599.9 | 32.53% | 29.66% |
| > 5600.0 | 41.60% | 42.11% |
| = 2.19 (*p*-value = 0.823) | | |
| *County* |  |  |
| Blekinge | 0.80% | 1.30% |
| Dalarna | 2.13% | 2.38% |
| Gävleborg | 4.00% | 3.46% |
| Gotland | 4.27% | 3.67% |
| Halland | 6.13% | 4.97% |
| Jämtland | 5.33% | 3.89% |
| Jönköping | 10.13% | 10.98% |
| Kalmar | 6.93% | 9.42% |
| Kronoberg | 2.67% | 4.58% |
| Norrbotten | 3.20% | 1.86% |
| Örebro | 1.60% | 1.56% |
| Östergötland | 5.33% | 6.27% |
| Skåne | 10.13% | 8.13% |
| Södermanland | 3.20% | 2.81% |
| Stockholm | 2.13% | 1.43% |
| Uppsala | 2.67% | 2.94% |
| Värmland | 2.93% | 2.46% |
| Västerbotten | 7.20% | 6.18% |
| Västernorrland | 4.00% | 3.55% |
| Västmanland | 0.80% | 0.95% |
| Västra Götaland | 14.40% | 17.21% |
| = 17.69 (*p*-value = 0.608) | | |
| N | 375 | 2313 |

*Note*: Based on data from Statistics Sweden

**Table A3**: Trade-offs (% milk yield reduction per cow)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Treatment |  | Control | *p*-valuesa |
| Mean | Mean |
| GHG emissions reduction | 0.496b |  | 0.396 | 0.302 |
|  | (0.278, 0.737)c |  | (0.141, 0.731) |  |
| Animal welfare: low improvement | 11.980 |  | 15.161 | 0.130 |
|  | (8.547, 15.719) |  | (10.692, 20.984) |  |
| Animal welfare: high improvement | 17.744 |  | 18.275 | 0.453 |
|  | (12.001, 25.296) |  | (11.790, 28.667) |  |
| Feed cost reduction | 0.386 |  | 0.537 | 0.234 |
|  | (0.116, 0.714) |  | (0.267, 0.918) |  |
| Biodiversity: low improvement | -3.507 |  | -5.098 | 0.726 |
|  | (-7.261, 0.900) |  | (-8.923, -1.337) |  |
| Biodiversity: high improvement | NS |  | 5.301 | 0.297 |
|  |  |  | (-0.628, 15.604) |  |
| Feed self-sufficiency | NS |  | NS |  |

*Notes*: a*p*-values are estimated from complete combinatorial test of Poe et al. (2005), bTrade-off values are estimated based on coefficients in treatment and control models, 95% confidence intervals are reported between parentheses

**Table A4**: Posterior beliefs about sustainability impacts of grass-based feeds by treatment1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Description | Treatment | Control | *p-val2* |
| GHG emissions | More grass-based feeds can contribute to reducing GHG emissions from my herd. | 3.63  (0.07) | 3.20  (0.08) | 0.000 |
|  |  |  |  |
|  |  |  |  |  |
| Biodiversity | More grass-based feeds can contribute to improvement in biodiversity on my farm. | 3.40  (0.08) | 3.33  (0.08) | 0.537 |
|  |  |  |  |
|  |  |  |  |  |
| Soil health | More grass-based feeds can contribute to improvement in soil health on my farm. | 3.36  (0.08) | 3.27  (0.08) | 0.433 |
|  |  |  |  |
|  |  |  |  |  |
| Milk yield reduction | More grass-based feeds can lead to lower milk yield in my herd. | 3.63  (0.08) | 3.56  (0.07) | 0.559 |
|  |  |  |  |
| Milk yield variability | More grass-based feeds can lead to increased milk yield variability in my herd. | 3.76  (0.07) | 3.66  (0.07) | 0.312 |
|  |  |  |  |
|  |  |  |  |  |
| Production costs | More grass-based feeds can contribute to reducing production costs on my farm. | 3.59  (0.07) | 3.27  (0.08) | 0.003 |
|  |  |  |  |
|  |  |  |  |  |
| Animal welfare | More grass-based feeds can contribute to improvement in animal welfare in my herd. | 3.61  (0.07) | 3.21  (0.08) | 0.000 |
|  |  |  |  |
|  |  |  |  |  |
| Feed self-sufficiency | More grass-based feeds can contribute to improvement in animal welfare in my herd. | 3.41  (0.09) | 3.47  (0.08) | 0.634 |
|  |  |  |  |
|  |  |  |  |  |
| Food-feed competition | More grass-based feeds can contribute to reducing the use of human-edible crops to directly feed cattle on my farm. | 3.63  (0.08) | 2.86  (0.09) | 0.000 |
|  |  |  |  |
|  |  |  |  |
| Observations |  | 176 | 199 |  |

*Notes*: *1*Beliefs elicited based on level of agreement or disagreement to different environmental, economic and social sustainability-related statements regarding grass-based feeds on a scale of 1 to 5 (1=strongly disagree to 5=strongly agree). *2p-*values fromtests of equality of means between treatment and control groups using two-sided t-test. Values in parentheses are standard deviations.

**Table A5**: Results of MXL models in WTP space showing how the impact of balanced sustainability information vary by farmer identities (

|  |  |  |
| --- | --- | --- |
|  | (1) | (2) |
|  | Interaction with treatment and pro-environmental identity | Interaction with treatment and pro-social identity |
| Mean |  |  |
| ASC | 16.661 | 4.039 |
|  | (24.049) | (8.512) |
| GHG emissions reduction | 1.626\*\* | 0.718\*\*\* |
|  | (0.805) | (0.270) |
| Animal welfare: low improvement | 29.376\*\* | 21.795\*\*\* |
|  | (14.584) | (4.514) |
| Animal welfare: high improvement | 50.519\*\*\* | 23.340\*\*\* |
|  | (19.496) | (6.355) |
| Feed cost reduction | 1.448\* | 0.695\*\* |
|  | (0.839) | (0.327) |
| Biodiversity: low improvement | 4.988 | -3.063 |
|  | (12.425) | (3.923) |
| Biodiversity: high improvement | 45.613\*\* | 11.870\* |
|  | (18.775) | (6.538) |
| Feed self-sufficiency | -0.157 | -0.245 |
|  | (0.770) | (0.225) |
| Milk yield reduction (scale parameter) | -0.071\*\*\* | -0.071\*\*\* |
|  | (0.008) | (0.008) |
| ASC **x** Treat | 63.582 | 8.448 |
|  | (41.016) | (13.006) |
| GHG emissions reduction **x** Treat | 0.898 | 0.220 |
|  | (1.283) | (0.399) |
| Animal welfare: low improvement **x** Treat | 25.833 | 0.825 |
|  | (23.801) | (6.061) |
| Animal welfare: high improvement **x** Treat | 10.277 | 9.318 |
|  | (27.867) | (8.886) |
| Feed cost reduction **x** Treat | 2.002 | 0.129 |
|  | (1.343) | (0.547) |
| Biodiversity: low improvement **x** Treat | 39.616\*\* | 3.050 |
|  | (19.512) | (6.551) |
| Biodiversity: high improvement **x** Treat | 5.609 | -5.355 |
|  | (24.193) | (8.104) |
| Feed self-sufficiency **x** Treat | 0.711 | 0.295 |
|  | (1.121) | (0.315) |
| ASC **x** | 1.345 | -3.405 |
|  | (3.907) | (5.545) |
| GHG emissions reduction **x** | 0.207 | 0.237 |
|  | (0.1232) | (0.173) |
| Animal welfare: low improvement **x** | 2.540 | 5.658\* |
|  | (2.329) | (2.950) |
| Animal welfare: high improvement **x** | 5.532\* | 4.869 |
|  | (30.993) | (3.784) |
| Feed cost reduction **x** | 0.154 | 0.126 |
|  | (0.138) | (0.223) |
| Biodiversity: low improvement **x** | 1.688 | 1.664 |
|  | (2.001) | (2.466) |
| Biodiversity: high improvement **x** | 6.702\*\* | 5.321 |
|  | (3.019) | (4.076) |
| Feed self-sufficiency **x** | -0.011 | -0.111 |
|  | (0.124) | (0.150) |
| ASC **x** Treat **x** | 10.064 | 4.244 |
|  | (6.532) | (7.838) |
| GHG emissions reduction **x** Treat **x** | 0.128 | 0.053 |
|  | (0.208) | (0.249) |
| Animal welfare: low improvement **x** Treat **x** | 4.513 | 1.198 |
|  | (3.837) | (3.915) |
| Animal welfare: high improvement **x** Treat **x** | 1.284 | 4.195 |
|  | (4.549) | (5.465) |
| Feed cost reduction **x** Treat **x** | 0.347 | 0.158 |
|  | (0.223) | (0.299) |
| Biodiversity: low improvement **x** Treat **x** | 6.336\*\* | 0.719 |
|  | (3.152) | (4.070) |
| Biodiversity: high improvement **x** Treat **x** | 1.173 | -3.412 |
|  | (3.925) | (5.271) |
| Feed self-sufficiency **x** Treat **x** | 0.118 | 0.187 |
|  | (0.189) | (0.022) |
| SD |  |  |
| GHG emissions reduction | -0.904\*\*\* | -0.836\*\*\* |
|  | (0.141) | (0.145) |
| Animal welfare: low improvement | -9.761\*\* | -8.987\*\*\* |
|  | (2.549) | (2.523) |
| Animal welfare: high improvement | 18.765\*\*\* | 18.300\*\*\* |
|  | (4.135) | (3.887) |
| Feed cost reduction | 1.212\*\*\* | 1.234\*\*\* |
|  | (0.157) | (0.158) |
| Biodiversity: low improvement | 1.195 | 1.263 |
|  | (1.119) | (1.142) |
| Biodiversity: high improvement | 5.487 | 7.158\* |
|  | (6.146) | (4.235) |
| Feed self-sufficiency | 0.630\*\*\* | 0.644\*\*\* |
|  | (0.180) | (0.171) |
| N | 6750.000 | 6750.000 |
| Log Likelihood | -2039.076 | -2040.135 |
| AIC | 4158.153 | 4160.270 |
| BIC | 4386.900 | 4389.018 |

*Notes*: Coefficients are point estimates of implicit trade-offs in terms of milk yield reduction (% milk yield reduction per cow). Treat is a binary variable that takes a value of one for farmers in the treatment arm and zero otherwise. Identity is a continuous variable captured by the scores for the environmental and social identity constructs, where higher scores imply stronger pro-environmental and pro-social farmer identities. Standard errors in parentheses, \* *p* < .1, \*\* *p* < .05, \*\*\* *p* < .01

**Table A6**: Results of MXL model in WTP space showing how the impact of balanced sustainability information vary by farmer prior knowledge (

|  |  |  |
| --- | --- | --- |
|  | (2) | (3) |
|  | Interaction with treatment and grass-related training | Interaction with treatment and agricultural education |
| Mean |  |  |
| ASC | 6.399 | 8.383 |
|  | (4.092) | (5.437) |
| GHG emissions reduction | 0.333\*\* | 0.242 |
|  | (0.136) | (0.185) |
| Animal welfare: low improvement | 13.610\*\*\* | 11.667\*\*\* |
|  | (2.240) | (3.244) |
| Animal welfare: high improvement | 16.677\*\*\* | 15.872\*\*\* |
|  | (3.258) | (4.159) |
| Feed cost reduction | 0.489\*\*\* | 0.382\*\* |
|  | (1.150) | (0.194) |
| Biodiversity: low improvement | -5.311\*\*\* | -3.310 |
|  | (2.197) | (2.717) |
| Biodiversity: high improvement | 4.693\* | 2.121 |
|  | (3.089) | (3.708) |
| Feed self-sufficiency | -0.057\*\*\* | 0.085 |
|  | (0.116) | (0.157) |
| Milk yield reduction (scale parameter) | -0.072\*\*\* | -0.073\*\*\* |
|  | (0.008) | (0.008) |
| ASC **x** Treat | 8.963 | -1.010 |
|  | (5.891) | (7.929) |
| GHG emissions reduction **x** Treat | 0.319\* | 0.278 |
|  | (0.177) | (0.265) |
| Animal welfare: low improvement **x** Treat | 0.472 | -3.937 |
|  | (3.055) | (4.570) |
| Animal welfare: high improvement **x** Treat | 4.682 | 0.863 |
|  | (4.215) | (5.766) |
| Feed cost reduction **x** Treat | 0.082 | -0.002 |
|  | (0.219) | (0.292) |
| Biodiversity: low improvement **x** Treat | 2.436 | -1.800 |
|  | (3.086) | (3.968) |
| Biodiversity: high improvement **x** Treat | 0.540 | 1.680 |
|  | (3.560) | (4.836) |
| Feed self-sufficiency **x** Treat | -0.013 | -0.271 |
|  | (0.156) | (0.223) |
| ASC **x** | 10.995 | 0.508 |
|  | (8.338) | (6.912) |
| GHG emissions reduction **x** | 0.271 | 0.213 |
|  | (0.251) | (0.227) |
| Animal welfare: low improvement **x** | 1.375 | 3.740 |
|  | (4.510) | (3.993) |
| Animal welfare: high improvement **x** | 0.294 | 1.470 |
|  | (5.298) | (4.897) |
| Feed cost reduction **x** | 0.222 | 0.223 |
|  | (0.313) | (0.256) |
| Biodiversity: low improvement **x** | 0.555 | -3.290 |
|  | (4.086) | (3.511) |
| Biodiversity: high improvement **x** | 0.615 | 4.474 |
|  | (4.744) | (4.488) |
| Feed self-sufficiency **x** | -0.157 | -0.310 |
|  | (0.237) | (0.198) |
| ASC **x** Treat **x** | -28.063\*\* | 7.107 |
|  | (12.348) | (10.294) |
| GHG emissions reduction **x** Treat **x** | -0.856\*\* | -0.225 |
|  | (0.390) | (0.327) |
| Animal welfare: low improvement **x** Treat **x** | -7.245 | 5.565 |
|  | (7.463) | (5.627) |
| Animal welfare: high improvement **x** Treat **x** | -9.130 | 3.001 |
|  | (8.116) | (7.259) |
| Feed cost reduction **x** Treat **x** | -0.989\*\* | -0.171 |
|  | (0.497) | (0.390) |
| Biodiversity: low improvement **x** Treat **x** | -3.395 | 6.149 |
|  | (6.184) | (5.356) |
| Biodiversity: high improvement **x** Treat **x** | -8.874 | -5.017 |
|  | (7.279) | (6.248) |
| Feed self-sufficiency **x** Treat **x** | 0.198 | 0.576\*\* |
|  | (0.375) | (0.290) |
| SD |  |  |
| GHG emissions reduction | -0.878\*\*\* | -0.904\*\*\* |
|  | (0.127) | (0.136) |
| Animal welfare: low improvement | -10.318\*\*\* | -9.781\*\*\* |
|  | (2.421) | (2.558) |
| Animal welfare: high improvement | 18.804\*\*\* | 18.34\*\*\* |
|  | (3.931) | (3.807) |
| Feed cost reduction | 1.228\*\*\* | 1.222\*\*\* |
|  | (0.154) | (0.152) |
| Biodiversity: low improvement | 0.632 | 1.021 |
|  | (0.913) | (0.998) |
| Biodiversity: high improvement | 7.084\* | 6.136 |
|  | (4.002) | (4.909) |
| Feed self-sufficiency | 0.661\*\*\* | 0.677\*\*\* |
|  | (0.184) | (0.175) |
| N | 6750.000 | 6750.000 |
| Log Likelihood | -2059.517 | -2061.230 |
| AIC | 4199.033 | 4202.459 |
| BIC | 4427.781 | 4431.207 |

*Notes*: Coefficients are point estimates of implicit trade-offs in terms of milk yield reduction (% milk yield reduction per cow). Treat is a binary variable that takes a value of one for farmers in the treatment arm and zero otherwise. Grass-related training is a binary variable that takes a value of one if farmer has previously participated in any grass-related feed training and zero otherwise. Agricultural education is a binary variable that takes a value of one if farmer has an agricultural education and zero otherwise. Standard errors in parentheses, \* *p* < .1, \*\* *p* < .05, \*\*\* *p* < .01

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1. We assess the validity of the latent constructs using average variance extracted (AVE), composite reliability (CR) and squared correlation (SC) among the latent constructs (Hair et al., 2017). The AVE statistics for environmental, social and economic identities (0.52, 0.57 and 0.46, respectively) are above the recommended threshold of 0.5, except for economic identity, which is close to 0.5. The CR statistics (0.76, 0.80 and 0.72, respectively) are above the recommended threshold of 0.7. Put together, the AVE and CR statistics indicate good convergent validity of the latent constructs. The AVEs are above the SCs among the latent constructs, which indicates good discriminant validity. [↑](#footnote-ref-1)