**SUPPLEMENTARY MATERIAL**

This is a supplementary material for the article “The relationship between commodity diversification and the adoption of technological innovations for Southeast beef cattle producers” It includes the following information:

**S1.** Technology adoption variables by diversification measures for the 140 Southeast beef cattle producers.

**S2.** Five Alternative Ordered Probit Regression Model Results for the 140 Southeast beef cattle producers

**S3.** Alternative Poisson Regression Model Results for the 140 Southeast beef cattle producers.

**S4.** Survey questions.

**Table S1**. Technology adoption variables by diversification measures for the 140 Southeast beef cattle producers.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Weather | Computer | Phone/Tablet | GIS | Auto feed | Enviro controls | Block chain | Growth Promot | Estrus Sync. | AI |
| *Produce Row Crop* | 25 | 27 | 55 | 11 | 20 | 31 | 8 | 5 | 6 | 25 |
| *Produce Vegetables* | 25 | 17 | 23 | 2 | 14 | 17 | 5 | 2 | 3 | 9 |
| *Produce Fruit* | 20 | 17 | 20 | 5 | 12 | 18 | 4 | 4 | 6 | 13 |
| *Produce Forest Products* | 21 | 15 | 18 | 8 | 13 | 18 | 7 | 3 | 2 | 13 |
| *Produce Poultry* | 16 | 24 | 27 | 6 | 18 | 20 | 5 | 4 | 6 | 21 |
| *Produce Other Livestock* | 30 | 34 | 42 | 14 | 27 | 31 | 6 | 10 | 16 | 24 |
| *Only Produce Beef* | 21 | 46 | 46 | 7 | 17 | 18 | 1 | 11 | 14 | 28 |

**Table S2:** Five Alternative Ordered Probit Regression Model Results for the 140 Southeast beef cattle producers.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variables** | **A.M #1** | **A.M #2** | **A.M #3** | **A.M #4** | **A.M #5** |
| **Diversification** |
| *Produce Row Crop* |  |  | -0.5122\*\* | -0.6159\*\* |  |
| *Produce Vegetables* |  |  |  | -0.6471\*\*\* | -0.5434\*\* |
| *Produce Fruit* |  |  |  | 0.4088\*\* | 0.4243\*\*\* |
| *Produce Forest Products* |  |  | 0.5673 | 0.5867 |  |
| *Produce Poultry* |  |  | 0.126 |  | 0.3082 |
| *Produce Other Livestock* |  |  | -0.4381\* |  | -0.4614\*\* |
| *Only Produce Beef* | -0.2229 |  | -0.5603 | -0.6864\*\* | -0.5648 |
| *Beef Forage Acreage* |  | -0.0012\* |  |  |  |
| *Row Crop Acreage* |  | 0.0002 |  |  |  |
| *Fruit Orc Acreage* |  | 0.0012 |  |  |  |
| *Vegetable Acreage* |  | -0.0071\* |  |  |  |
| *Poultry Acreage* |  | -0.0011 |  |  |  |
| *Other Livestock Acreage* |  | -0.0016 |  |  |  |
| *Forest Acreage* |  | (omitted) |  |  |  |
| *Produce Vegetables\* Produce Fruit* |  |  |  |  |  |
|  |  |  |  |  |  |
| *01* |  |  | 0.7894\*\*\* |  |  |
| *10* |  |  | -0.3956 |  |  |
| *11* |  |  | -0.5999\*\* |  |  |
| *Produce Poultry\* Produce Other Livestock* |  |  |  |  |  |
| *01* |  |  |  | -0.5635\*\* |  |
| *10* |  |  |  | 0.1498 |  |
| *11* |  |  |  | -0.1924 |  |
| *Produce Forest Products\* Produce Row Crop* |  |  |  |  |  |
| *01* |  |  |  |  | -0.4702\* |
| *10* |  |  |  |  | 0.8771\*\* |
| *11* |  |  |  |  | -0.2802 |
| **Producer perceptions** |
| *Enrolled in Indemnity Program* | 0.4398\*\* | 0.4218\*\* | 0.4695\*\* | 0.4949\*\*\* | 0.4852\*\*\* |
| *No. of Conservation Practices* | 0.2581\*\*\* | 0.2292\*\* | 0.2455\*\* | 0.2340\*\* | 0.2391\*\* |
| *Sales Rep Most Accurate* | 0.4931\*\*\* | 0.5325\*\*\* | 0.5679\*\*\* | 0.4866\*\*\* | 0.5278\*\*\* |
| *Variation in Unexpected Expenses* | -0.2735 | -0.3748\* | -0.4000\* | -0.3962\* | -0.3887\* |
| *Variation in Cattle Price* | 0.3802\* | 0.3209 | 0.3680\* | 0.3875\* | 0.3912\* |
| *No. Adaptation Strategies* | 0.15 | 0.1617 | 0.1671 | 0.1685 | 0.1457 |
| **Producer demographic characteristics** |
| *Beginning Farmer* | 0.5132\*\* | 0.4760\*\* | 0.5141\*\* | 0.4656\*\* | 0.4693\*\* |
| *Married* | -0.3734\* | -0.3231 | -0.2454 | -0.2913\* | -0.2955\* |
| *Some College or Higher* | 0.1126 | 0.2089 | 0.1257 | 0.1054 | 0.0846 |
| *Age* | 0.0190\* | 0.011 | 0.0184 | 0.0142 | 0.0134 |
| *High Extension Interaction* | -0.7455 | -0.6461 | -0.7438 | -0.7853 | -0.7742 |
| **Farm characteristics** |
| *Stocker* | 0.4164\* | 0.3438 | 0.4660\* | 0.4300\* | 0.415 |
| *No. Pastures* | 0.0663\*\* | 0.0670\*\* | 0.0657\*\* | 0.0723\*\*\* | 0.0761\*\* |
| *Production Total Acres* | -0.0004 | 0.0007 | -0.0004\*\* | -0.0004\*\* | -0.0005\*\* |
| *No. Operations* | 0.4398\*\* | 0.4218\*\* | 0.4695\*\* | 0.4949\*\*\* | 0.4852\*\*\* |
| *State Fixed Effects* | Yes | Yes | Yes | Yes | Yes |
| Observations | 140 | 140 | 140 | 140 | 140 |
| **Note:** **\* p<0.1; \*\* p<0.05; \*\*\*p<0.01** |  |  |  |  |

**Table S3:** Alternative Poisson Regression Model Results for 140 Southeast beef cattle producers.

|  |  |  |
| --- | --- | --- |
| **Variables** | **Coefficients**  | **Standard Errors** |
| **Diversification** |  |
| *Produce Row Crop* | -0.1569\* | 0.0842049 |
| *Produce Vegetables* | -0.1535\* | 0.0805072 |
| *Produce Fruit* | 0.0815 | 0.0523296 |
| *Produce Forest Products* | 0.119 | 0.1019679 |
| *Produce Poultry* | 0.1051 | 0.0656111 |
| *Produce Other Livestock* | -0.1282 | 0.0851017 |
| *Only Produce Beef* | -0.1559 | 0.1296912 |
| **Producer perceptions** |  |
| *Enroll in Indemnity Program* | 0.1598\*\*\* | 0.0617327 |
| *No. of Conservation Practices* | 0.0611\* | 0.0317516 |
| *Sales Rep Most Accurate* | 0.0633\* | 0.0373865 |
| *Variation in Unexpected Expenses* | -0.0889 | 0.0810301 |
| *Variation in Cattle Price* | 0.1048\* | 0.0614783 |
| *No. Adaptation Strategies* | 0.0413 | 0.0318069 |
| **Producer demographic characteristics** |  |
| *Beginning Farmer* | 0.1191\* | 0.0687278 |
| *Married* | -0.0903\* | 0.0477402 |
| *Some College or Higher* | 0.0417 | 0.0958613 |
| *Age* | 0.0039 | 0.0035392 |
| *High Extension Interaction* | -0.2049 | 0.1576645 |
| **Farm characteristics** |  |
| *Stocker* | 0.109 | 0.0804998 |
| *No. Pastures* | 0.0169\*\* | 0.0076783 |
| *Production Total Acres* | -0.0001\*\* | 0.0000562 |
| *No. Operations* | 0.1287\*\*\* | 0.0352524 |
| *Constant* | 0.4531 | 0.3042367 |
| *State Fixed Effects* | Yes |  |
| Observations | 140 |  |
| **Note:** **\* p<0.1; \*\* p<0.05; \*\*\*p<0.01** |  |

**S4.** Survey Questions

What other types of production are at **your largest beef cattle operation**?

* Just beef cattle and forage (including hay), no other types of production (6)
* Row crop (1)
* Fruit and orchard (2)
* Vegetable (3)
* Poultry (7)
* Other livestock (not beef cattle) (4)
* Timber or Forest Products (5)

What conservation practices have you adopted or would you consider adopting? Please answer considering **your largest beef cattle operation in the Southeast.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | No, would never adopt (1) | Would consider adopting (2) | Already adopted (3) | I do not know this practice (4) | Adopted but stopped practicing (5) |
| Incorporation of legumes (1)  |  |  |  |  |  |
| Poultry litter or other slow release N (2)  |  |  |  |  |  |
| Silvopasture (3)  |  |  |  |  |  |
| Forage stockpiling (4)  |  |  |  |  |  |
| Biochar (5)  |  |  |  |  |  |
| Incorporate cool season forage (6)  |  |  |  |  |  |

Over the next 10 years, to what extent are you concerned with the following threats to your farm operation?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Not at all concerned (1) | Slightly concerned (2) | Somewhat concerned (3) | Moderately concerned (4) | Extremely concerned (5) |
| Longer dry periods and drought (1)  |  |  |  |  |  |
| More frequent extreme rains (3)  |  |  |  |  |  |
| Increases in saturated soils and pond water (4)  |  |  |  |  |  |
| Increased heat stress in forage/pasture (5)  |  |  |  |  |  |
| Increased heat stress in livestock (6)  |  |  |  |  |  |
| Increase incidence of pest and disease (7)  |  |  |  |  |  |
| Increasing input costs (8)  |  |  |  |  |  |
| Decreasing cattle price (9)  |  |  |  |  |  |

How likely are you to implement any of the following practices to lower the possibility of damage from weather events?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Very Unlikely (1) | Unlikely (2) | Neither Likely nor Unlikely (3) | Likely (4) | Very Likely (5) |
| Consider irrigation (1)  |  |  |  |  |  |
| Change forage species (2)  |  |  |  |  |  |
| Change cattle genetics (3)  |  |  |  |  |  |
| Take out more/better insurance policies (4)  |  |  |  |  |  |
| Add additional water sources to pasture (6)  |  |  |  |  |  |
| Add additional shade to pasture (7)  |  |  |  |  |  |

Please select an option on the scale below. The value of 0 stands for “not willing to take a risk at all” and the value 10 for “very willing to take a risk”. With the values in between you can grade your assessment.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 0 (Not willing) (1) | 1 (2) | 2 (3) | 3 (4) | 4 (5) | 5 (6) | 6 (7) | 7 (8) | 8 (9) | 9 (11) | 10 (Very willing) (10) |
| Production (1)  |  |  |  |  |  |  |  |  |  |  |  |
| Market and prices (2)  |  |  |  |  |  |  |  |  |  |  |  |
| External financing (3)  |  |  |  |  |  |  |  |  |  |  |  |
| Agriculture in general (4)  |  |  |  |  |  |  |  |  |  |  |  |

What conservation practices have you adopted or would you consider adopting? Please answer considering **your largest beef cattle operation in the Southeast.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | No, would never adopt (1) | Would consider adopting (2) | Already adopted (3) | I do not know this practice (4) | Adopted but stopped practicing (5) |
| Incorporation of legumes (1)  |  |  |  |  |  |
| Poultry litter or other slow release N (2)  |  |  |  |  |  |
| Silvopasture (3)  |  |  |  |  |  |
| Forage stockpiling (4)  |  |  |  |  |  |
| Biochar (5)  |  |  |  |  |  |
| Incorporate cool season forage (6)  |  |  |  |  |  |

Have you implemented or adopted any of the innovative practices or technologies listed below?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Not adopted, not interested (1) | Not adopted, interested in adopting (2) | Yes adopted, currently using (4) | Yes adopted, but not currently using (5) |
| GPS technology (1)  |  |  |  |  |
| GIS technology (2)  |  |  |  |  |
| Weather monitoring with weather stations (3)  |  |  |  |  |
| Smartphones/tablets for farm management (4)  |  |  |  |  |
| Computers to track or manage finances (5)  |  |  |  |  |
| Automatic feeding or watering for animals (6)  |  |  |  |  |
| Blockchain techology (7)  |  |  |  |  |
| Automated environmental controls for animal housing (8)  |  |  |  |  |

From the list below, which livestock management practices would you consider practicing?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Currently practice/use (1) | Would be interested in exploring (2) | Would not be interested (3) | I do not know what this practice is (4) |
| Growth promoting technologies (implants, ionophores) (1)  |  |  |  |  |
| Energy supplements (2)  |  |  |  |  |
| Protein supplements (3)  |  |  |  |  |
| Fat supplementation (4)  |  |  |  |  |
| Weaning (5 months or earlier) (5)  |  |  |  |  |
| Estrus synchronization (6)  |  |  |  |  |
| Artificial insemination (8)  |  |  |  |  |

**In the last 3 years,** did you enroll or receive payment from any of the following programs?

|  |  |  |  |
| --- | --- | --- | --- |
|  | Did not enroll (1) | Enrolled, did not receive payment (2) | Enrolled, received payment (3) |
| NRCS Climate Smart Projects (2)  |  |  |  |
| NRCS Conservation Reserve Program (CRP) (9)  |  |  |  |
| NRCS Environmental Quality Incentive Programs (EQIP) (8)  |  |  |  |
| NRCS cost-share programs (4)  |  |  |  |
| USDA Livestock Forage Program (5)  |  |  |  |
| USDA livestock indemnity program (6)  |  |  |  |
| Other USDA or another governmental program for agricultural losses due to weather (7)  |  |  |  |
| Other governmental agricultural payments (crop insurance, indemnity payments, other program payments) (1)  |  |  |  |

**Last year,** did you enroll or receive payment from any of the following programs?

|  |  |  |  |
| --- | --- | --- | --- |
|  | Did not enroll (1) | Enrolled, did not receive payment (2) | Enrolled, received payment (3) |
| NRCS Climate Smart Projects (2)  |  |  |  |
| NRCS Conservation Reserve Program (CRP) (9)  |  |  |  |
| NRCS Environmental Quality Incentive Programs (EQIP) (8)  |  |  |  |
| NRCS cost-share programs (4)  |  |  |  |
| USDA Livestock Forage Program (5)  |  |  |  |
| USDA livestock indemnity program (6)  |  |  |  |
| Other USDA or another governmental program for agricultural losses due to weather (7)  |  |  |  |
| Other governmental agricultural payments (crop insurance, indemnity payments, other program payments) (1)  |  |  |  |

In the last 3 years, what was the greatest source of variation **on your net cash farm income for your largest beef cattle operation in the Southeast?**

* Cattle prices (1)
* Input costs (2)
* Forage availability and yield (3)
* Loss of animals (6)
* Unexpected expenses (4)
* Other (5) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Please rate the accuracy of the agricultural production information distributed by the following sources with 1 being very low accuracy and 5 being very high accuracy.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 1- Very low (1) | 2- Low (2) | 3- Neutral (3) | 4- High (4) | 5- Very high (5) |
| Cooperative Extension (1)  |  |  |  |  |  |
| United States Department of Agriculture (2)  |  |  |  |  |  |
| Other governmental agencies (3)  |  |  |  |  |  |
| Other producers (5)  |  |  |  |  |  |
| Youtube, Tiktok, other media sources (6)  |  |  |  |  |  |
| Consultants (7)  |  |  |  |  |  |
| Agricultural sales representatives (seed, fertilizer, input, tractor/equipment, etc.) (8)  |  |  |  |  |  |