Appendix A Regression Controls

To select controls for the animal equation, we draw on the animal science literature to inform controls we include in the model.

Inside X_{ijt}:

- Economic Controls
  - Cost of 16% dairy ration
  - Income over feed cost
  - Replacement cost (Beef Price \$/lb $\times$ 1400 - Cost of Replacement Heifer)
  - Time Trend
- Biological Controls
  - Calving Month (Indicator)
  - Test Month (Indicator)
  - Birth Year (Indicator)
  - Lactation Number (Indicator)
  - Holstein (Indicator)
- Management Controls
  - Proportion of Lactation Milked Three Times in a Day
  - Herd Size (deviations from average)
  - Lactation Length (Days in Milk of record)

Appendix B First Stage Estimates

The first stage equation for our model uses past variation in a sire's evaluation which occurs at the national level as a source of exogenous variation:

$$z_{ij} = \alpha_{0j} + \gamma \Delta z_{ij} + \beta_0 X_{ijt} + \eta_{ijt}$$

While this prediction is time-invariant (selection occurs only once), the residual η_{ijt} will still be time-variant because of the term X_{ijt}. Due to the presence of X_{ijt}, the first stage essentially treats the same cow at different points in time as entirely separate cows who happen to have the same values of z_{ij}. This means that when when we examine the PTA investment for one cow at two different lactations, it essentially treats these as two adoption decisions; by deciding to let the animal keep producing, the manager implicitly adopts the genetics again. This is not necessarily problematic, but does necessitate throwing out anything above first lactation to properly understand how the culling decision interacts with adoption of genetics.

One implication of this approach is that the first stage will helps us understand the trait investments for animals that survive. Table **??** shows the results of the first stage and the coefficients

on animal level variables. Both OLS and fixed effects are shown to get a sense for what level of variation is important. For example, lactation length and lactation number are both significant in predicting z, which implies that cows that have a larger trait investment are milked longer and are more likely to not be culled in their first year. Milking the cow three times per day is significant in the OLS specification but not in the fixed effects, implying that farms that choose higher investments in production traits also milk more intensively at the herd level. Holstein cows are also most likely to have the highest investment in production traits, which is to be expected given their comparative advantage in high volume production.

Differences across production traits is mostly seen in the culling decision. Without herd fixed effects, cows that are kept past the first lactation have higher trait investment for both fat and protein. Once herd fixed effects are used, fewer differences are seen across lactations, considering only animal level variation. For fat, only second lactation cows have marginally more fat investment than first lactation cows. For protein, all later lactation cows have higher investments in protein (on the order of one pound more). One thing that can be learned from these results is that adoption decisions and other management decisions are inextricably linked. Specifically, cows that have a high PTA investment are more likely to be kept, milked longer, and milked more intensively.

Table 1: First Stage Regression

	PTA Fat		PTA Protein	
	OLS	FE	OLS	FE
Δz_{ij}	0.499***	0.500***	0.495***	0.496***
	(0.000648)	(0.000613)	(0.000550)	(0.000514)
Lactation No.=2	1.589***	0.368*	1.793***	0.954***
	(0.265)	(0.207)	(0.193)	(0.157)
Lactation No.=3	2.220***	-0.195	2.789***	1.132***
	(0.519)	(0.409)	(0.376)	(0.310)
Lactation No.=4	3.164***	-0.393	3.675***	1.254***
	(0.766)	(0.594)	(0.569)	(0.461)
Lactation No.=5	3.839***	-0.787	4.718***	1.610***
	(0.999)	(0.786)	(0.746)	(0.605)
Proportion Milked 3x	1.528***	-0.310	1.210***	-0.0692
	(0.481)	(0.687)	(0.351)	(0.382)
Herd Size	0.0000154	-0.000717	-0.0000608	-0.000657
	(0.000258)	(0.000572)	(0.000198)	(0.000519)
Lactation Length (Days)	0.00640***	0.00561***	0.00559***	0.00522***
	(0.00108)	(0.000913)	(0.000781)	(0.000678)
Holstein	1.475	3.191***	3.260***	2.707***
	(1.475)	(0.561)	(0.791)	(0.656)
Observations	1641022	1641022	1641022	1641022
Adjusted R^2	0.249	0.303	0.281	0.333

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$