Characteristic space analysis of agricultural technology adoption

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Motivation

- Farm productivity-adoption puzzle: Low agricultural productivity in Sub-Saharan Africa (SSA) attributed to low adoption of modern agricultural technologies. Why are farmers not adopting available productivity improving technologies especially hybrid varieties ?

  1. Institutions and environment: Price stabilization policies
  2. Farmer characteristics: dominant reason in the adoption literature.
  3. Technology characteristics: less prior literature.

- This paper is aimed at explicitly accounting technology (improved maize) characteristics in adoption analysis
  1. What is the optimal mix of characteristics in a variety?
  2. What is the predicted rate of adoption if a particular characteristic is bred into a variety?

Hybrid Maize(Corn) Example

- Most adoption literature concerned with product space. Why are farmers not adopting hybrid maize, inorganic fertilizer, conservation agriculture, insurance or credit schemes?
- Framing of such research questions imply
  1. The technology or product is perfect for the farmers
  2. If some farmers adopt or while others do not adopt, there is something wrong to be fixed with the non-adopters
  3. Failure of social scientists to guide breeding programs, e.g. answering, what will be the change in adoption if a new characteristic like drought tolerance is introduced.
- In Malawi alone there are more than 40 hybrid maize varieties in the market with different characteristics, some with very few users.

Understanding adoption through IO models

- Few variety adoption papers have incorporated variety characteristics in two ways:
  1. Farmer subjective ratings of attributes: e.g. Smale.2001.Econ.Dev.Cult.Change.; Lunduka,Fisher,Snapp.2012.Food Policy, Useche et al.2009.AJAE
  2. Discrete choice experiments: Ward et al.2014.World Development.
- Three gaps in this literature as compared to IO models
  1. Ignores supply side yet variety seed market is potentially oligopolistic
  2. Ignores objective definition of characteristics as Lancaster emphasized.
  3. Choice experiments ignore the production aspect of variety adoption
- Contribution:(1).Use objective characteristics from variety registration records and on-farm experiments. (2).Incorporate supply side

Understanding adoption through IO models

- Characteristic definition: "an objective and universal property of a good (input)" Lancaster (1971).Examples:
  1. Beauty is not a characteristic but color is a characteristic.
  2. Cookability is not a characteristic but flint/dent is a characteristic.
  3. IO examples: BLP(1995/2004) use horsepower/engine size of a car; Nevo (2001) uses calories, sodium and fiber content.

Empirical Strategy

- Using micro-BLP (2004) notation. Each farmer i maximizes indirect utility μ for maize variety j where $j = 0$ is the outside variety (local variety):

$$\mu_{ij} = \sum_k x_{jk} \widetilde{\beta_{ik}} + \xi_j + \epsilon_{ij} \tag{1}$$

where

$$\widetilde{\beta_{ik}} = \beta_k^b + \sum_r z_{ir} \beta_{kr}^0 + \beta_k^u v_{ik} \tag{2}$$

- Insert 2 into 1 and rearrange

$$\mu_{ij} = \sum_k x_{jk} \beta_k^b + \xi_j + \sum_{kr} x_{kr} z_{ir} \beta_{kr}^0 + \sum_k x_{jk} v_{ik} \beta_k^u + \epsilon_{ij} \tag{3}$$

- Use multinomial and mixed multinomial logit on 3

Supply side

- Following Nevo (2001), a finite number F of seed companies each producing a subset of varieties adopted by farmers, $\mathscr{F}_f$, maximize profits:

$$\Pi_f = \sum_{j \in \mathscr{F}_f} (p_f - mc_j) Ms_j(p) - C_f \tag{4}$$

- Price-cost margin as a function of shares of each variety (from demand analysis)

$$p - mc = \Omega^{-1} s(p) \tag{5}$$

Data sources

1. Household survey data: 2010-2013 CIMMYT Variety Adoption Study. About 2400 observations from 1923 farm households.
    - Dependent variable: Varieties grown by a farmer in 2012/13 season (About 40 unique varieties)
    - Other variables: Household size,age,plot area, years of schooling, gender,fertilizer subsidy dummy and seed subsidy dummy.
2. Characteristics data (for top 9 varieties): Seed company websites, CIMMYT publications, DIIVA data, Ministry of Agriculture's Variety Release Registry
    - Variety age, seed company, days to maturity,flint dummy,yield,price,drought tolerance dummy, MSV resistance dummy and GLS resistance dummy

Summary stats: Household data

Table: Household summary statistics (N=2458)

Variety	Prop	Hsize	Age	Area	Schooling	Gender	Seed S
Local	0.33	5.44	47.10	0.53	6.55	0.81	0.49
DK8033	0.08	5.64	42.81	0.41	7.54	0.90	0.64
DK8053	0.08	5.89	42.01	0.54	6.93	0.90	0.60
DK9089	0.04	5.83	41.75	0.45	6.19	0.90	0.66
MH18	0.06	6.35	44.75	0.45	5.83	0.90	0.44
PAN53	0.03	5.88	46.60	0.52	6.18	0.94	0.56
SC403	0.20	5.69	44.63	0.38	6.52	0.81	0.63
SC627	0.13	5.62	44.57	0.41	6.70	0.83	0.56
SC719	0.05	5.85	42.20	0.47	7.72	0.91	0.60
All	1.00	5.80	44.05	0.46	6.68	0.88	0.58

Summary stats: Characteristics data

Table: Variety characteristics

Variety	Years	Mat	Flint	Yield	P	DT	MSV	GLS
SC403	14	100	Flint	4500	320	Yes	Yes	No
SC627	13	125	Flint	9000	320	No	Yes	Yes
DK8033	10	112.5	Dent	8000	342	Yes	Yes	Yes
DK8053	5	125	Flint	10000	342	No	Yes	Yes
MH18	22	125	Flint	6000	365	No	No	No
SC719	4	130	Dent	11500	400	Yes	Yes	Yes
PAN53	5	137.5	Flint	9000	365	Yes	Yes	Yes
DK9089	3	117.5	Flint	10000	342	No	Yes	Yes
Local	>50		Flint		33	-	-	-

Revealed relevance of characteristics:Theory

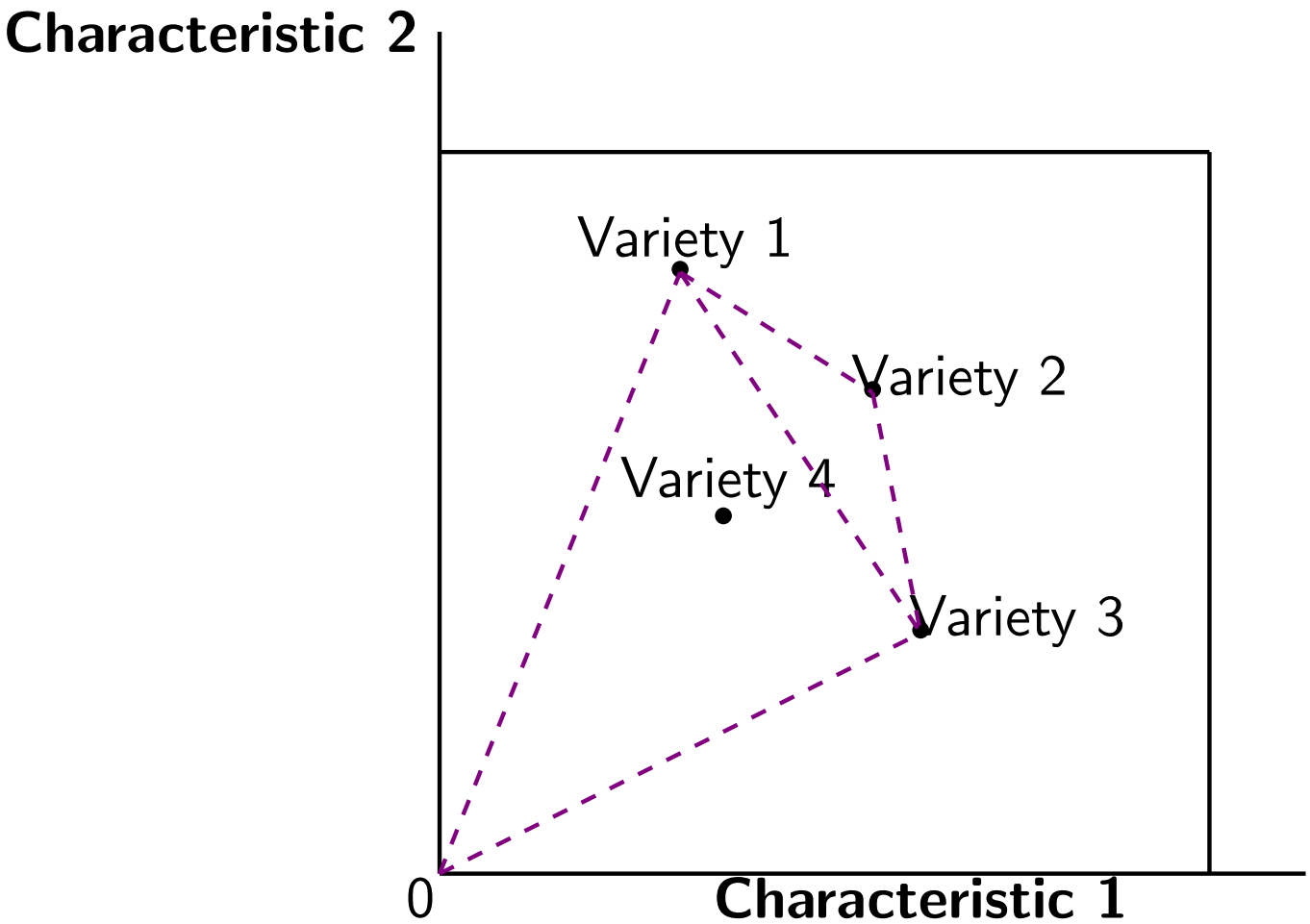

Figure: Variety characteristics frontier

Revealed relevance of characteristics(1)

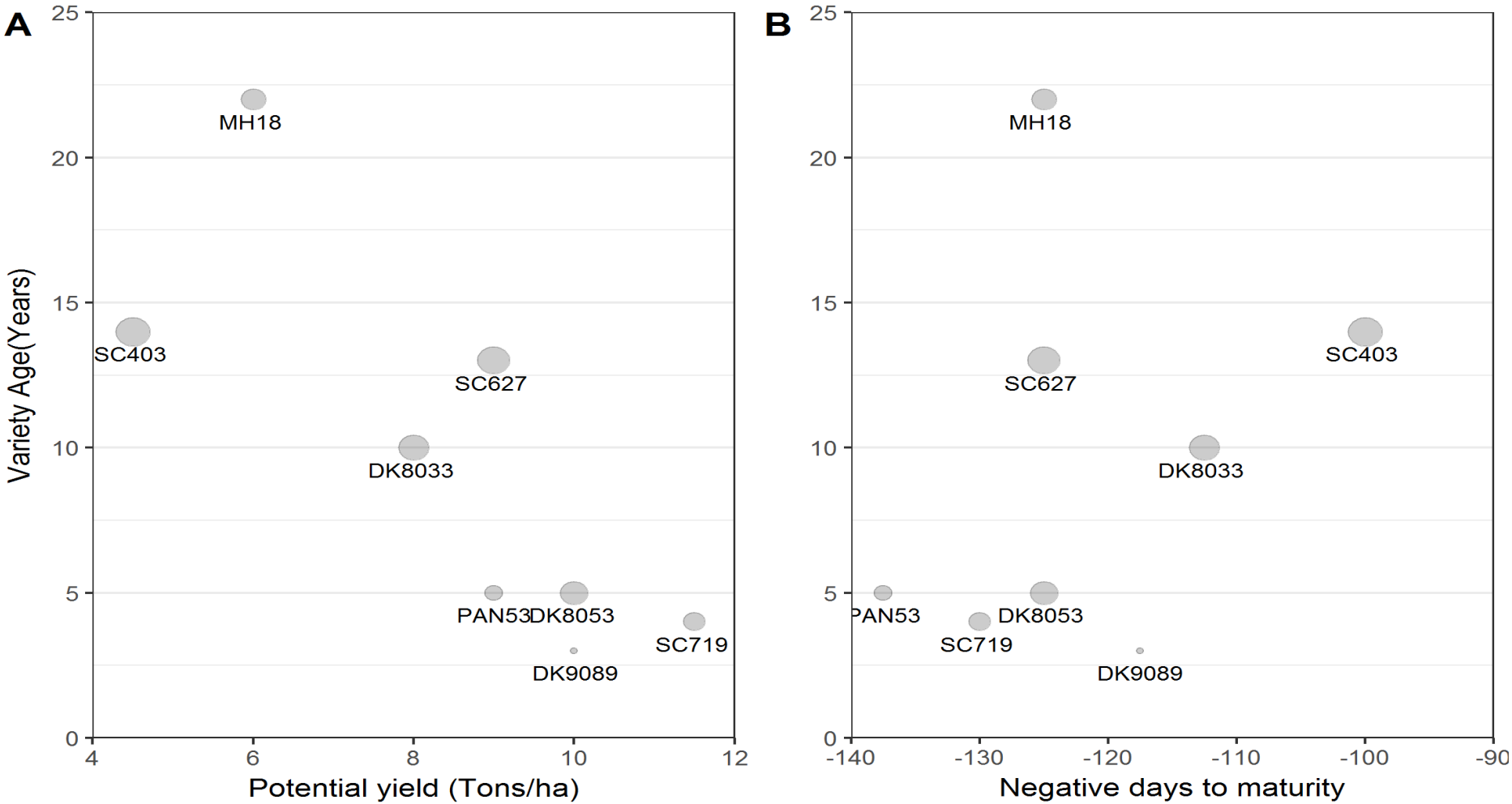

Figure: Yield,variety age and days to maturity

Revealed relevance of characteristics(2)

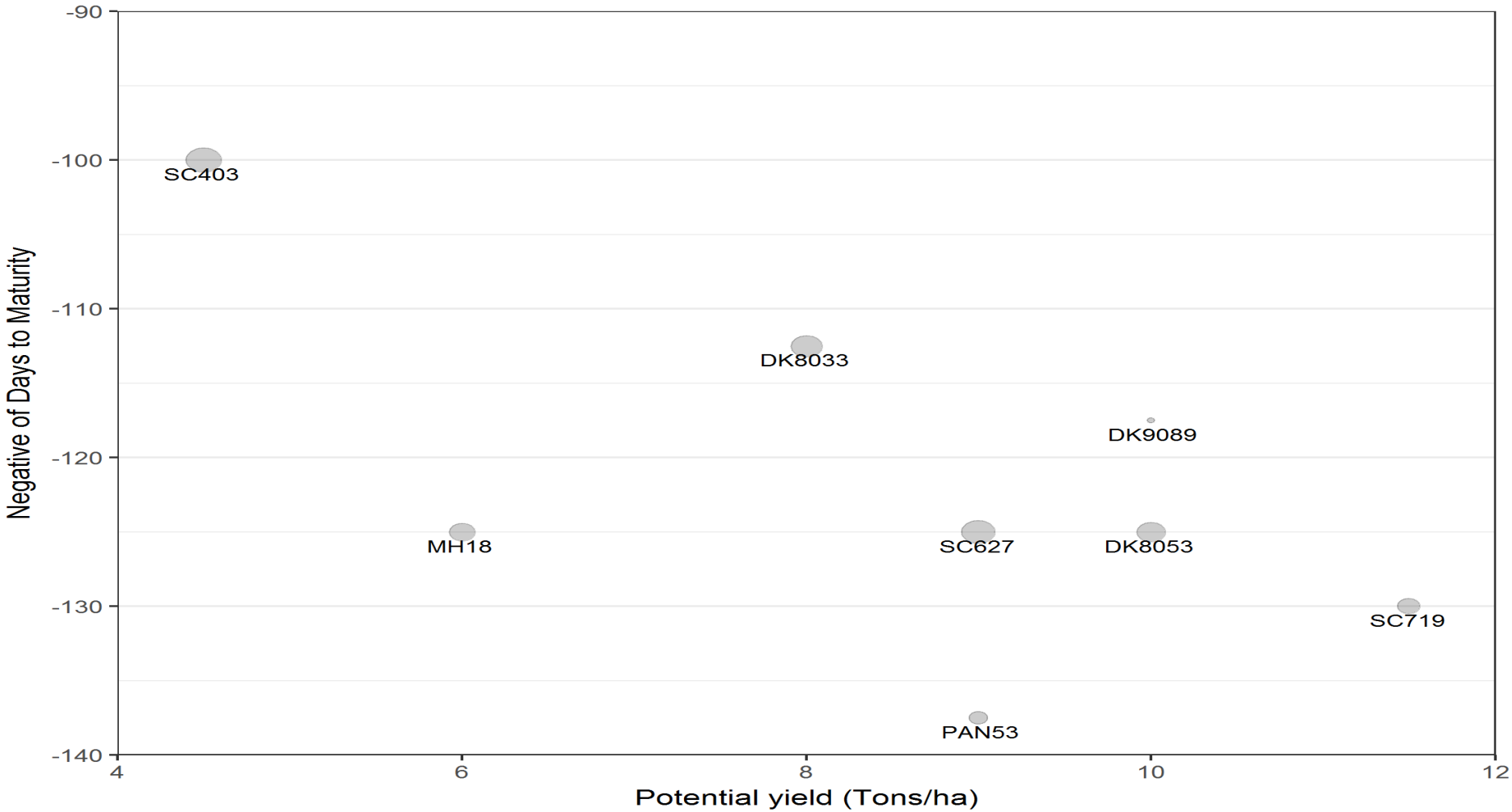

Figure: Yield and days to maturity

Logit results

Table: Logit results (1)

Variety	Age	Hhsize	Sch	Gend	Fert S	Seed S
DK8033	-0.02***	0.03	0.05**	0.45*	-0.25	0.91**
DK8053	-0.02***	0.07**	0.08***	0.48*	-0.51	0.97**
DK9089	-0.03***	0.06	0.05	0.46	-0.54	1.35**
MH18	-0.01	0.11***	0.04	0.47	-0.46	0.27
PAN53	0.004	0.03	0.08**	1.13**	0.98**	-0.44
SC403	-0.01***	0.05**	0.01	-0.14	-0.35	0.98***
SC627	-0.01**	0.03	0.03*	-0.04	0.19	0.16
SC719	-0.02**	0.07*	0.03	0.63*	-0.51	0.87*

Logit results (Variety characteristics)

Table: Logit results (2)

Variety	Price	Var.age	Maturity	Flint	Yield
DK8053	-0.16	-9.03***	-6.58***	364.63***	0.07
DK9089	5.96	15.44***	-35.72***	534.78***	0.18
MH18	1.18	17.99***	-6.70***	157.05***	0.05
PAN53	-0.004	-12.77***	2.55	143.06***	-0.02
SC403	1.72	-7.14***	-6.62***	200.71***	0.01
SC627	-1.16	5.88***	-3.04**	251.13***	0.04
SC719	5.91***	39.56***	-33.43***	362.93***	0.2

Conclusion and future research

- Early maturity, flinty nature and variety age key characteristics for variety adoption
- Price (seed cost) and yield which food policies and breeding programs focus on are not as important for hybrid variety choice (Note: Local variety is not included)
- Next steps (need suggestions):
  1. Calculate predicted shares and carry out simulations on incorporating a characteristic on a variety in the set
  2. Calculate price-cost margins. Address the question: Does the farm input subsidy program (includes maize seed subsidy) reinforce seed companies' market power in the seed industry?
  3. Discuss socially optimal maize variety differentiation and policy suggestions (following theoretical frameworks by Lancaster.1975.AER and Jones.1988.JPE)
- THANK YOU