On the Value of Agricultural Biodiversity

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Biodiversity in Agriculture

- Diversity within and among species found in crop and domesticated livestock systems, including wild relatives, interacting species of pollinators, pests, parasites, and other organisms (Qualset et al. 1995, Wood & Lenné 1999)
- Complemented by wild relatives stored in gene banks and breeders' collections (Smale 2006)

One strand of the Econ literature

- Conservation of landraces in situ
- Drivers?
- Brush et al. (1992) => improved varieties in Mexico
- Van Dusen and Taylor (2005) => Missing markets and agroecological heterogeneity - Mexico
- Attributes that farmers seek in these crops?
- Birol et al. (2006; 2009) => Mexico, Hungary
- Gauchan et al. (2008) => Nepal
- Emedaes et al. (2009) => Uganda

Second strand: Economic valuation

- Crop biodiversity is very important for both the functioning of ecological systems and the generation of a vast array of ecosystem services (e.g., Naeem et al. 1994, Tilman & Downing 1994, Tilman et al. 1996, Wood & Lenné 1999, Loreau & Hector 2001)
- The value of biodiversity => from the value of the final goods and services it produces
- Biodiversity is an input into the production of these final goods and services

- This approach requires the specification of production functions that embed the ecosystem processes and ecological functions that connect biodiversity and ecosystem services - Perrings (2010)
- Biodiversity is a part of natural capital, and the flow of services is the interest on the capital - (Kontoleon et al. 2009)
- Focus: Production and Diversity

Biodiversity increases the level at which certain ecosystem services are provided

- Higher-diversity systems result in greater yields than do lower-diversity systems (Tilman et al. 2005)
- The sampling effect or the selection probability effect (Aarssen 1997; Huston 1997; Tilman et al. 2005 Loreau 2000)
- The productive exploitation of environmental heterogeneity and niche partitioning (Tilman & Downing 1994, Tilman et al. 1996, Lehman & Tilman 2000; Di Falco & Chavas 2009)

More Diversity More Species Complementarities?

- Complementarities among crop species imply an efficient use of total available resources both in time and in space (Trenbath 1974, Harper 1977, Ewel 1986, Vandermeer 1989, Loreau and Hector)
- Multiple crop species can also reduce the implication of price and production risk (Baumgärtner & Quaas 2008;

Di Falco & Chavas 2009)

- Allow farmers to market their produce several times throughout the year

Facilitative interaction

- Some species can buffer against harsh environmental conditions
- The probability that some of these species can react in a functionally differentiated way to disturbance of the system and changing environmental conditions increases with the number of functionally different species.
- Insurance

(MacArthur 1955, Chapin & Shaver 1985, Lawton & Brown 1993, Naeem & Li 1997, Naeem 1998, Petchey et al. 1999, Trenbath 1999, Borrvall et al. 2000, Baumgärtner & Quaas 2009; Bertness & Callaway 1994, Mulder et al. 2001)

Resilience ≈ Insurance

- Diverse gene pools represent a form of insurance against ecological collapse
- The greater is the extent of diversity, the greater is the capacity for adaptation to stresses and the maintenance of the ecosystem's organisational and functional structure:

  Resilience
- Holling (1973, 1986)
- Stability is the propensity of a population to return to some kind of equilibrium following a disturbance
- Weather shocks for instance

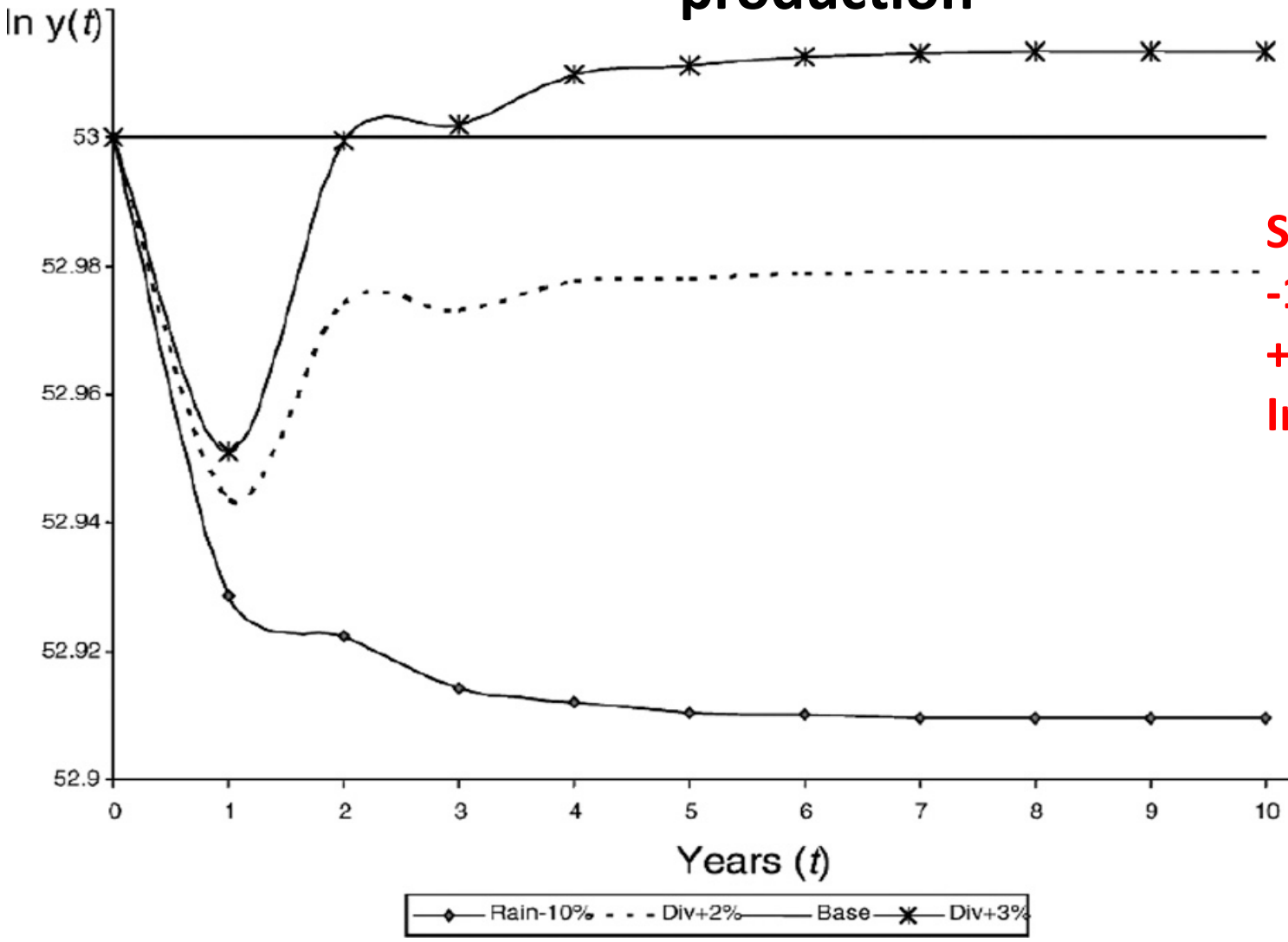
Evidence – mostly in Developing world

Table 1 Summary of studies on biodiversity, productivity, and risk

Study	Area	Dimension of diversity	Findings
Evenson & Gollin (1997)	Different countries	Rice genetic improvement	Genetic improvement has an economic payoff. It also expands the land race pool
Smale et al. (1998)	Punjab of Pakistan	Intraspecific diversity in wheat	Crop genetic diversity is positively correlated with mean yields and is negatively correlated with the variance of yields
Widawsky & Rozelle (1998)	China	Rice	The number of planted varieties reduces both the mean and the variance of rice yield
Di Falco & Perrings (2003, 2005)	Italy	Interspecific cereals	Crop genetic diversity is positively correlated with mean yields and is negatively correlated with the variance of yields. This relation can be weakened by access to financial support from the European Union
Di Falco & Chavas (2006)	Italy	Intraspecific wheat	Biodiversity supports productivity and reduces the risk of crop failure
Di Falco et al. (2007)	Ethiopia	Intraspecific wheat	Biodiversity can reduce the variance of yields
Omer et al. (2007)	UK	On-farm functional biodiversity	Increases in biodiversity can lead to increases in productivity in modern agricultural landscapes
Di Falco & Chavas (2009)	Ethiopia	Intraspecific barley	Biodiversity supports productivity and reduces the risk of crop failure. These results are more relevant in the presence of degraded land
Di Falco et al. (2010)	Ethiopia	Intraspecific cereals	More biodiversity and more productivity

Di Falco and Chavas 2008:

Permanent reduction of rainfall in south of Italy – cereals production



Sc 3: like 2 – + 3% Shannon Index

Sc 2: -10% rainfall + 2% Shannon Index

Sc 1: -10% rainfall

Modelling Farmer's Behavior

- From an economist's perspective, the study of diversification is the natural place to start (Chavas and Di Falco 2012, *JAE*)
- Choice of a more diversified regime, why?
- An agroecosystem can be modeled in the context of a production process (Barbier 2008) => multi outputs, multi inputs and Risk (Certainty equivalent)
- Productivity and Risk (different moments) aspect of more diversity decision
- Decompose each of these components into complementarity, scale and concavity effects
- Ethiopia

We found

- On the productivity/scope side, we find large complementarity benefits, providing incentives to diversify
- Tempered by (non)-concavity effects that provide incentives to specialize
- The complementarity component is found to dominate, thus generating incentive to diversify
- How risk affects diversification? It finds that risk of crop failure in diversification decisions.
- The estimated diversification benefit amounts to 17 percent of the expected revenue for an average farm

Conclusions

1. Collaboration between economists, agroecologists, and other natural scientists is essential for future progress in valuing the contribution of crop biodiversity to ecosystem services.

2. Critical challenges (e.g., endogeneity, unobservable heterogeneity, external validity) => availability of better data sets (e.g. panel data) can help with these issues

3. The dynamic implications of crop biodiversity need to be elucidated both theoretically and empirically

4. The interaction between crop biodiversity and other dimensions of biodiversity (i.e., soil biodiversity) should be explored

5. Climate Change surveys in Africa indicate the role of Diversity as key adaptation strategy: short run Vs. long run response?

Thank you

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