An economist perspective on the Bioeconomy

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Outline

- The Bioeconomy in the context of resource Economics
- Innovation and transition
- Indirect effect of transition to the bioeconomy
- Regulation and acceptance
- Conclusion

The Bio economy defined

- The ‘bioeconomy’ is defined as

“ The part of the economy that utilizes new biological knowledge for commercial and industrial purposes, and for improving human welfare” (Enriquez-Cabot 1998).

- It produces foods, fuels, fibers, pharmaceuticals, chemicals, even computer memory
- It is a natural resource based industrial system

The new vs. old bioeconomy

- The traditional bio-economy to large extent relied on fermentation (wine, beer, kimchi, baked goods)
- The modern bio economy utilizes developments in molecular biology
  - Biotech
  - Biofuel
  - Green chemistry

The Bio economy leads to major changes

- Replaces non renewables with renewables
- Is associated with new mode of R&D
- Increases value of natural resource and agricultural income
- Provides new agribusiness opportunities and creates rural jobs in processing and production of new products (cosmetics, oils, coloring)
- Challenges food and energy systems
- Its future depends on polices and institutions

Bioeconomy and climate change

- Bioeconomy can reduce GHG emission by
  - Transition to renewable biofuels
  - Improved crop productivity thus reducing agricultural foot print
- It can accelerate adaptation to climate change
  - By allowing to develop new crops system in response to varying conditions

The Bioeconomy in the context of the Resource Economics

- It is useful to distinguish between
  - Non renewable resources
    - Oil, coal, iron etc.
  - Renewable resources
    - Water, fish, trees
- Optimal management of both (under full information) is the outcome of dynamic optimization (max net present value) subject to equation of motion constraints

The differences between renewable and non renewables

- The stock of renewable resource can be stabilized when harvesting=growth
- When the stock of a non renewable resource is known
  - extraction is reducing the stock
- When the stock of non renewables is not known –
  - If there is a continuous searches for new deposits and known reserves has been increasing and
    - Discoveries > extraction
    - non renewables – are treated like renewables and
    - Prices do not increase over time
- When extraction > discoveries- the reality of non renewability is recognized – that is start to happen now (peak oil)
- Another process that allows to renew the non renewable is recycling- it works with aluminum cans but not with oil.

The different dynamics of renewable vs. non renewable

category	Non renewable resource	Renewable resource
Equation of motion	Change of resource stock= minus extraction (recycling is an exception)	Change of stock=growth-extraction
Steady state	Impossible – resource stock declines over time (recycling is an exception)	Feasible= but if extraction is greater than growth extinction occurs
Resource price	Increases over time	Stable in steady state
Incomplete knowledge	New discoveries may increase known stock and reduce prices over time	Adaptive learning and adjustment of extraction

The role of technology

- Resources are producing outputs- and technology can affect productivity
  - Technology can increasing input use efficiency of
    - Extraction
    - Transport
    - Processing
    - Production
- There is substitutions between resources, human capital and physical capital
- History of civilization is full with manifestation of increased in utilization of natural resources

Categories of renewable: Harvesting (hunting) vs. husbandry (farming)

- Two types of renewables:
  - hunting gathering vs. farming,
  - fishery vs. aquaculture
- Farming includes
  - Breeding
  - Raising (feeding, disease and pest protection)
  - Harvesting
- Tradeoff between cheaper harvesting vs. cost of breeding and raising

Evolution of harvesting systems

- Gradual improvement of plants systems:
  - Better raising (Synthetic fertilizers ,pest control strategies , advanced irrigation)
  - Better breeding (Selective breeding- biotech)
- The species involved in the transitions are modified
  - Modern cow is bred to be a docile milk machine
  - Could not survive in wilderness
- Farming evolves as harvesting become more expensive and resources not sufficient

Factors Contributing to Evolution of farming system

- Population and income growth increase demand for harvested products
- Improvements in harvesting technology increases supply- **Extraction exceeds growth – more product needed**
- Technological change in breeding and protection
- Marginal cost of farming declines **it becomes profitable**
- It productivity expands due to further learning
- Farming expands
  - Takes lion share of output

- **Farming allowed survival of wild populations- co-existence of agriculture and wilderness**

The transition from harvesting to farming is gradual

- It happened in food production years ago
  - For a while coexistence of farming and hunting
  - Farming gets cheaper
- It is happening in aquaculture now
  - The challenge is technological economical and environmental
- Biofuel and green chemistry are part of the process

The bio economy is associated with transition

- From renewables to non renewables (biofuel, green chemistry)
- From harvesting to husbandry (some biotech)
- Improvement of husbandry system
  - Better breeding and raising (Biotechnology)
- Development of new value added industries many in rural areas
  - Refineries to fuels and fine chemicals
  - Processing of new bio base products close to source

The bioeconomy and educational industrial system (EIS)

- Much of the new biotechnologies are the outcome of basic innovations of the EIS
- University innovations that are patented and licensed to companies (start up/corporation)
- Public and private research serve a complementary role
- Heavy regulations lead to concentration of technology providers (they are the only one that can finance the licensing)

Orphan sectors and public action

- Private sector will underinvest in technologies serving the poor and orphan products
- Need for public sector and NGOs to fill the gaps
  - Incentives to private effort
  - Public investment in product development
- Importance of mechanisms to provide access to enable technologies needed to develop technologies for poor
- Important for development countires to develop local research capacity – to engage in bioeconomy
  - Embrapa is a good example

Challenges of the bioeconomy

- Challenges
  - Outputs of the bioeconomy may be renewables but it relies on non renewable input (fertilizers)
    - Fixing nitrogen is a major challenge and $50 billion 0portunity
  - Overall greenhouse gas emissions and other externalities of new products – may be greater than of the products they replace
  - Some bioeconomy activities will reallocate resources from food production
- Transition to bioeconomy is a great research and regulation challenge

Bioeconomy and food challenges

- Introduction of bio products may lead to increase of food prices
- But bioeconomy development may complement food supply expansion
- Need increases in food productivity and mechanism to protect the poor from food price inflation
  - Resources needed for biofuel and green chemistry will be obtained by expanded ag production
  - Use of underutilized resources to produce new products

Agricultural Biotechnology Has Already Made a Major Difference

- Emerged in the early 1990s, taking advantage of the discovery of the genome

Crop	Global Production Share (2010)	Increased Supply	Reduced Prices
Corn	25%	6-15%	10-16%
Soybean	81%	12-32%	15-22%
Cotton	64%	18-37%	15-40%

- Reduced GHG emissions and toxic chemical use
- Impact on prices and supply will be much greater with expanded adoption
- The potential is much larger with sound research and regulation

Trait category	a. Primary survey							b. Secondary survey		
	Highest stage attained by 2004						**Total for Survey 1**	Expected commercialization		**Total for Survey 2**
	Publication only	Field trials			Regulatory	Commercialized				
		Initial (1-3)	Mid-stage (4-9)	Late-stage (≥10)				by 2010	2010-2015	
Proteins and amino acids	33	47	12	7	1	0	**100**	8	6	**14**
Oils and fatty acids	15	22	8	5	2	1	**53**	4	4	**8**
Carbohydrates and sugars	32	65	16	10	0	0	**123**	2	1	**3**
Micronutrients and functional metabolites	47	15	3	1	0	0	**84**	0	2	**2**
Reduced non-nutrients, allergens, or toxins	18	6	0	2	0	1	**9**	3	0	**3**
Ripening, freshness, or shelf life	19	41	10	6	5	2	**83**	4	3	**7**
Esthetics and convenience	15	21	5	2	1	1	**43**	0	3	**3**
Fiber quality for digestibility and pulping	22	16	5	1	0	0	**44**	5	1	**6**
Plant bioremediation	2	8	0	0	0	0	**12**	0	0	**0**
Multiple or unspecified quality traits: 'seed composition' and 'feed quality'	0	2	2	3	0	0	**7**	2	1	**3**
Total	**203**	**243**	**61**	**37**	**9**	**5**	**558**	**28**	**21**	**49**

Double cropping already works

- Double cropping – can increase output, reduce soil erosion and in waste
- Is done in Brazil and Argentina- allow the global increase in soybean
- Only 10% in the US
- We can go further
- Moving to 50% double cropping with 25% yield increase can lead to 50% increase in overall output

Biofuels are a Work in Progress

- Corn and sugarcane ethanol are economically viable
- Corn ethanol contributes to balance of trade, energy security, farm income, and higher food prices
- Learning occurs
  - Cost of corn ethanol decreased 70% from 1980-2000
  - Cost of sugarcane ethanol decreased 70% from 1976-2005
- There are limitations on 1st generation biofuels, but second generation biofuels from straw and grasses will figure in the U.S. agricultural future
- It will produce not only biofuels but also feedstock for feed
- The key is investment in research

Intensification

- We need 50% more output from the same land with less fertilizers
- Research- history tells us – helped America and the world increase productivity in the past
- Input use efficiency rise is needed for the future
- Sustainability means increased reliance on the bioeconomy –food fuel chemicals
- Much of the increase in productivity in the past relied on fertilizers- now they are more scare
- Challenge –reduce dependence

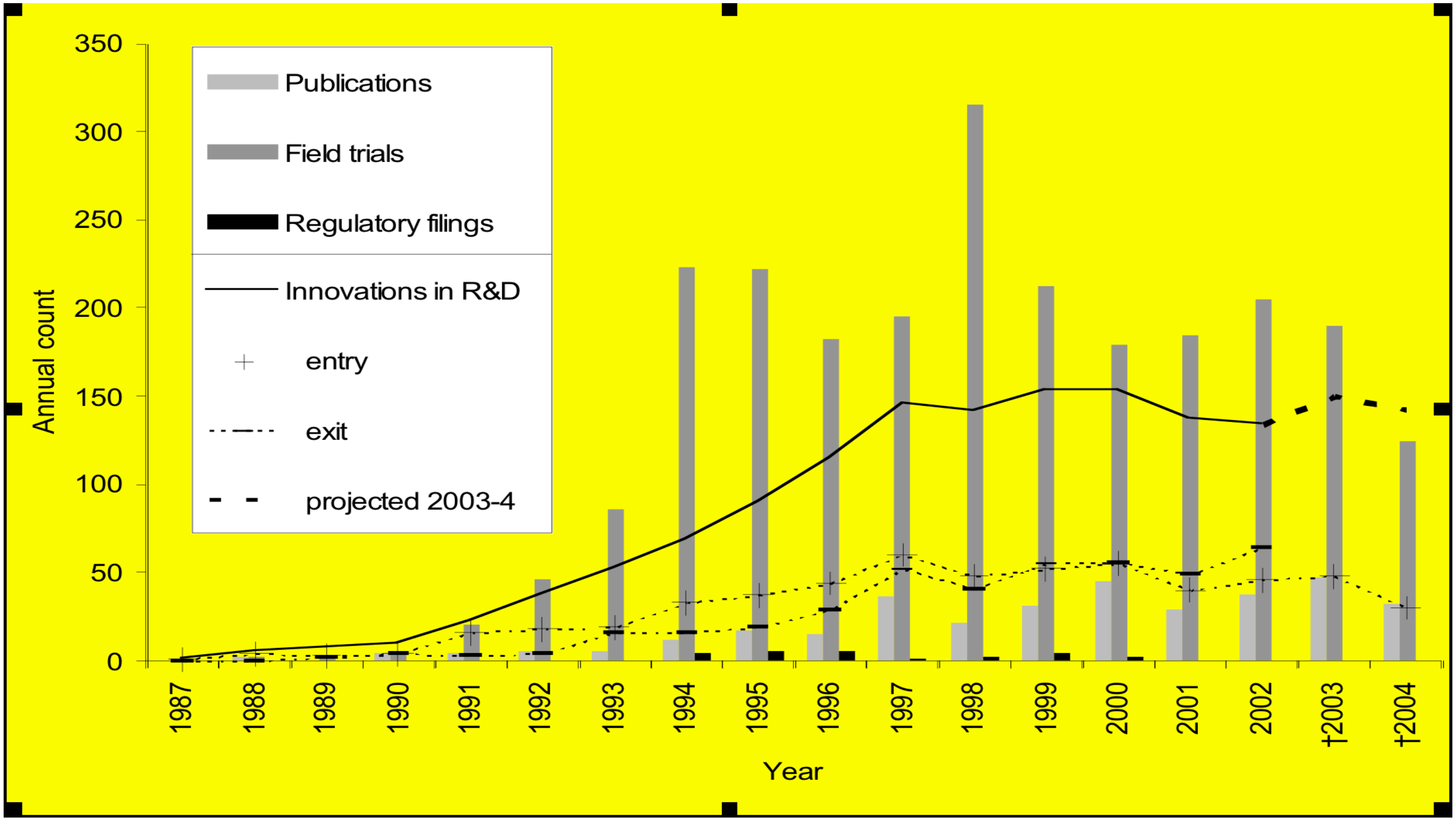
Adjustments

- Bioeconomy – inherent risks
  - Weather dependence
  - Diseases
- Addressed by
  - Inventories
  - Spatial diversification
  - Insurance
  - Redundancy
- Bio-stuff is costly to move
  - New distributive systems of refineries aimed to reduce transport costs

Introduction of bioeconomy may be challenged

- New innovations have faced resistance (automobiles, evolution, tomatoes…)
  - May take long to overcome
  - Affected by beliefs, political economy
- Leads to bans and restrictions
  - True for old bioeconomy (prohibition)
  - As well as GMOs
  - It is part of growth

Excessive regulation has a price-contraction of Ag biotech in 1999



Ingo Potrykus - Regulations and their costs delayed or prevented introduction of health improving traits

Conclusions: attitudes toward bioeconomy

- There is a desire to move towards a renewable economy
  - But resistance against much of the actions it entails
  - Some is based on basic economics but
- Traditional environmental instinct is to preserve, protect, and conserve
  - Some perceive Sustainability as steady state nirvana
  - Precautionary approaches
  - **But evolution exists and change occurs**
- Need to adapt and take calculated risks
- **Note all non renewable is undesirable: if it is abundant and clean it is sound**
- **We should not go "bioeconomy crazy"**

Agriculture is much more than food

- Traditional agricultural problem – low farm incomes suggested a need for new sources of income – the bioeconomy provides it.
  – It increases product mix of farming systems
  – It is likely also to shift jobs (in refining processing quality control etc.) to rural areas
- But food is first – need policies to assure food availability and affordability
  – The bioeconomy requires expanding the region of agricultural production and productivity of agricultural and in particular food commodities

Many opportunities to increase agricultural resource utilization

- Productivity levels of much of the world are very low
  - Yields can double or triple in much of the world to reach higher levels available elsewhere
  - It becomes more feasible in a globalized more connected economy
- Peaks yields can and have risen: 1.5-2.0% increase in max corn yield
- Double cropping of some grains substantially raised value of output/land in Argentina and Brazil

Much land can be added to ag without environmental effect

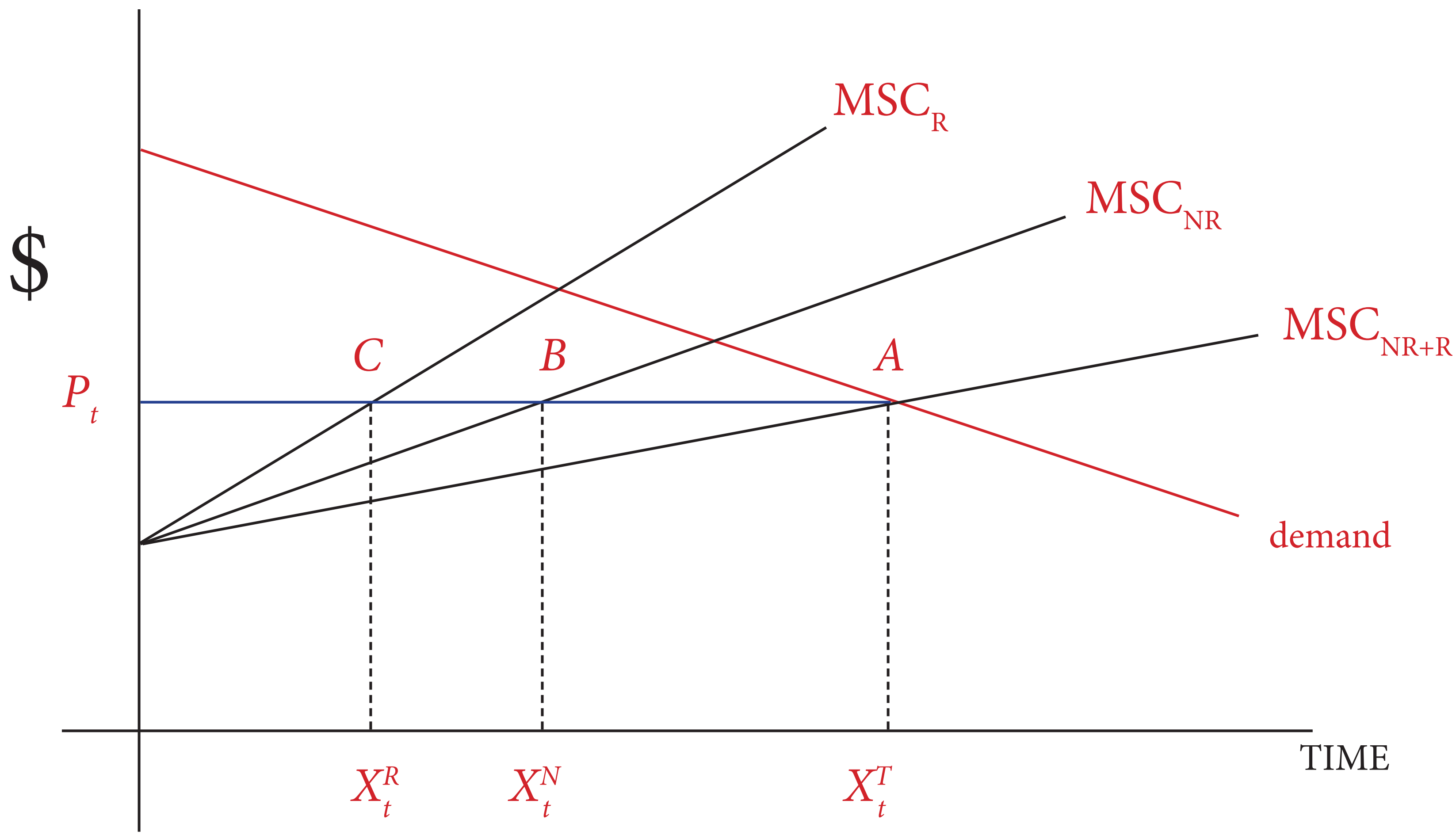
- Brazil - massive lands are underutilized. Marcos Jank showed that 10% of world liquid fuel need can be met with feasible modest expansion of agriculture
- Africa
- Eastern Europe
- Vast Rangelands

Not all of us are dead in the long run

- Modern biology combined with information technology provides us with advanced tools: technical base for the bioeconomy.
- Necessary condition for implementation: sound polices and institutions-for (among others)
  - Knowledge development and sharing
  - Finance of innovation and development
  - Environmental trade and technological regulations
  - Integrated ag energy and environmental policies
- The development of these institution and policies is the challenge of social and policy sciences

thanks

Co-existence of renewable and non renewable-(similarly farming hunting)



Over time the cost of renewables decline their share increase