

Modelling the impact of a macro-algae sector on the Western Isles (Na h-Eileanan Siar)

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The Western Isles is a chain of islands in the Atlantic Ocean off the Northwest coast of Scotland.

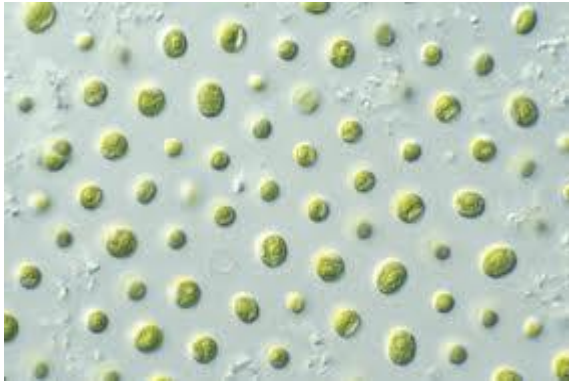
Aim of the work

- Modelling the local economic impacts of algae production in the Western Isles Region.
- We model and measure the potential economic benefits, for the local community, of using seaweed to generate bio gas via anaerobic digestion.
 - Anaerobic digestion: “natural process in which microorganisms break down organic matter, in the absence of oxygen, into biogas (CO₂ and methane) and digestate”
- We do this using AMOS a computable general equilibrium model originally developed for the Scottish economy (Harrigan et al., 1991).
- Why the WI:
 - A representative community within the Biomara geographic area west of Scotland and the northern parts of Northern Ireland and the Republic of Ireland.
 - Ongoing local knowledge of macro algae harvesting
 - Existing set of accounts on which we can build our model.
- Why anaerobic digestion?
 - This is the technology that is closest to being operational at present.

Macro-Algae

- Seaweed is a type of Macro Algae.
- We can distinguish between Macro and Micro Algae.
 - Macro Algae is a collective term for various types of seaweed while micro algae are just smaller organisms.
- Biomass from both micro and macro algae.
- Given the current state of technology macro algae is judged to be more feasible (Lewis et al 2011).

Micro and Macro Algae



Fermentation vs. Anaerobic Digestion

- We can use the seaweed to produce
 - bioethanol or biobutanol via fermentation
 - or generate methane through Anaerobic Digestion.
- Bioethanol is an established sector worldwide
- Anaerobic digestion is a widely applied technology:
 - in particular in some emerging economies (India, China),
 - European countries as well (Germany, Sweden) and there is a working example in the Western Isles.

Modelling local economic impacts

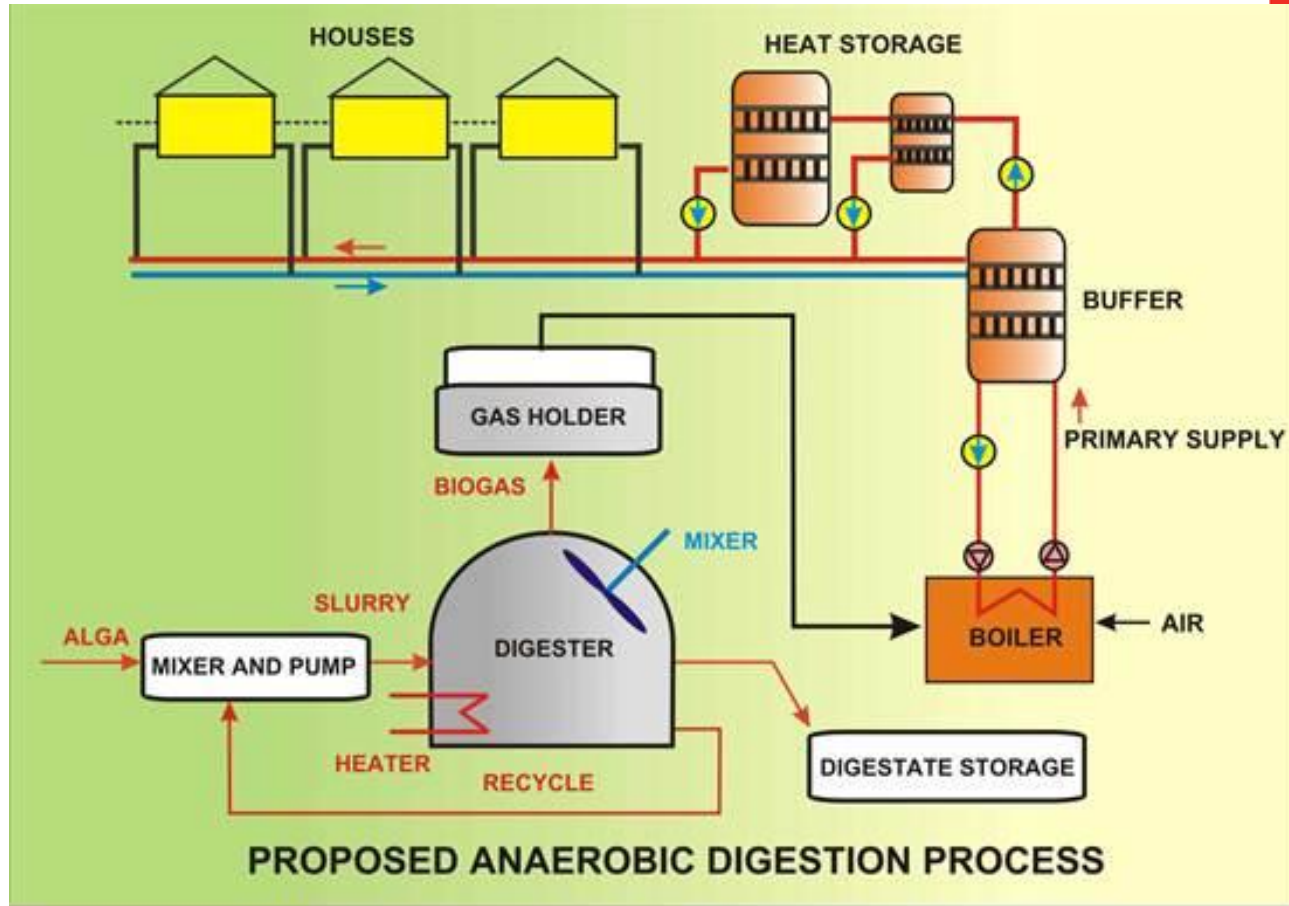
- Related studies on biofuels use mainly Input-Output analysis (Swenson, 2006; Hodur and Leistritz, 2008; Cunha and Scaramucci, 2006; Kulišić et al., 2007; Low and Isserman, 2009).
- Few CGE models (Kretshmeier and Peterson, 2010; Dixon et al., 2007; Ignacuk and Dellink, 2006) .
- Multi-sectoral modelling techniques
 - Computable General Equilibrium (CGE) model
- CGEs allow for greater flexibility.
 - Possibility of imposing supply constraints
 - endogenous prices
 - different treatment of production structures (input substitution possible)
 - market imperfections

Western Isles data

- 2008 Social Accounting Matrix (SAM) for Western Isles
 - Updated version from 2003 SAM (Roberts, 2005)
 - New information, need for rebalancing (cross-entropy method)
- We have identified two new sectors (survey of the existing literature, augmented by the work of Sanderson, 2006):
 - Algae cultivation
 - Anaerobic digestion and district heating
 - The algae cultivation sector supply inputs to the anaerobic digestion sector which in turn produce bio fuel for the local community

Algae and Anaerobic Digestion Sectors

4000
tonnes
(dry)
algae

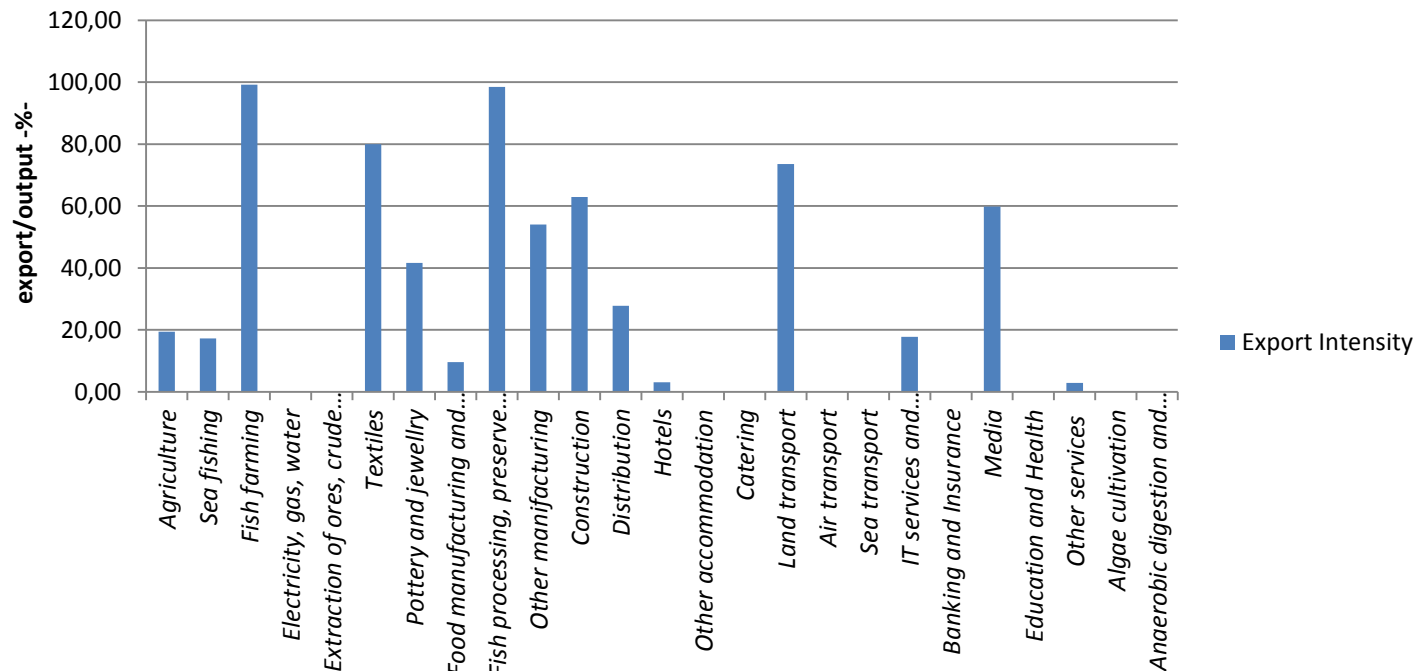


Annual energy requirements: 1184 MWh for space and water heating. 42 households in Western Isles

Western Isles data

- GDP: £358 Millions
 - 0.34% of Scottish GDP
 - 0.03% of UK GDP
- Trade deficit: £154 Millions
- GVA Algae cultivation is 0.028% of total Value added
- GVA Anaerobic Digestion is 0.001% of total Value added
- Population Western Isles 26,502. Scotland 5.2 Million.

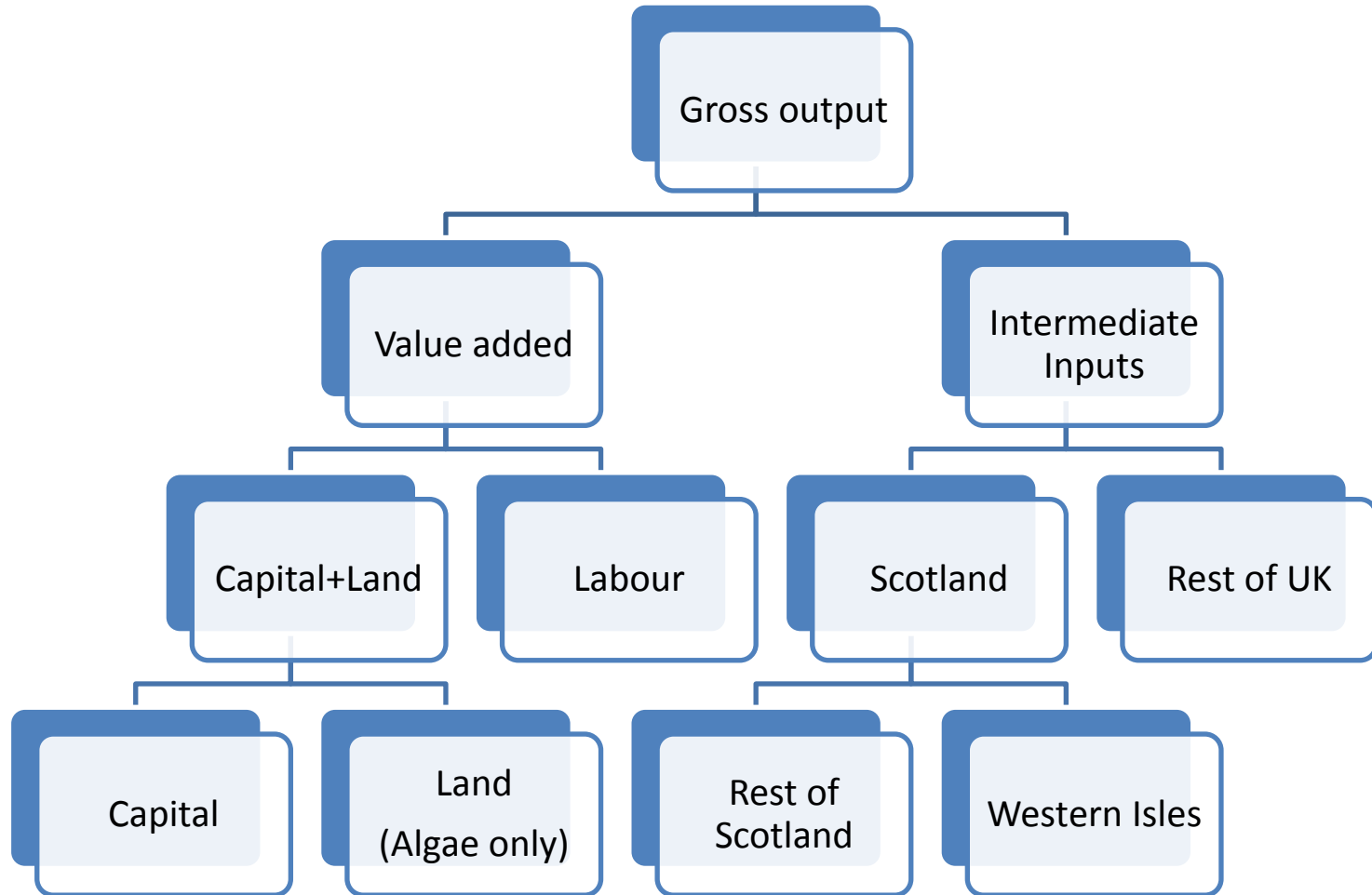
Export Intensity



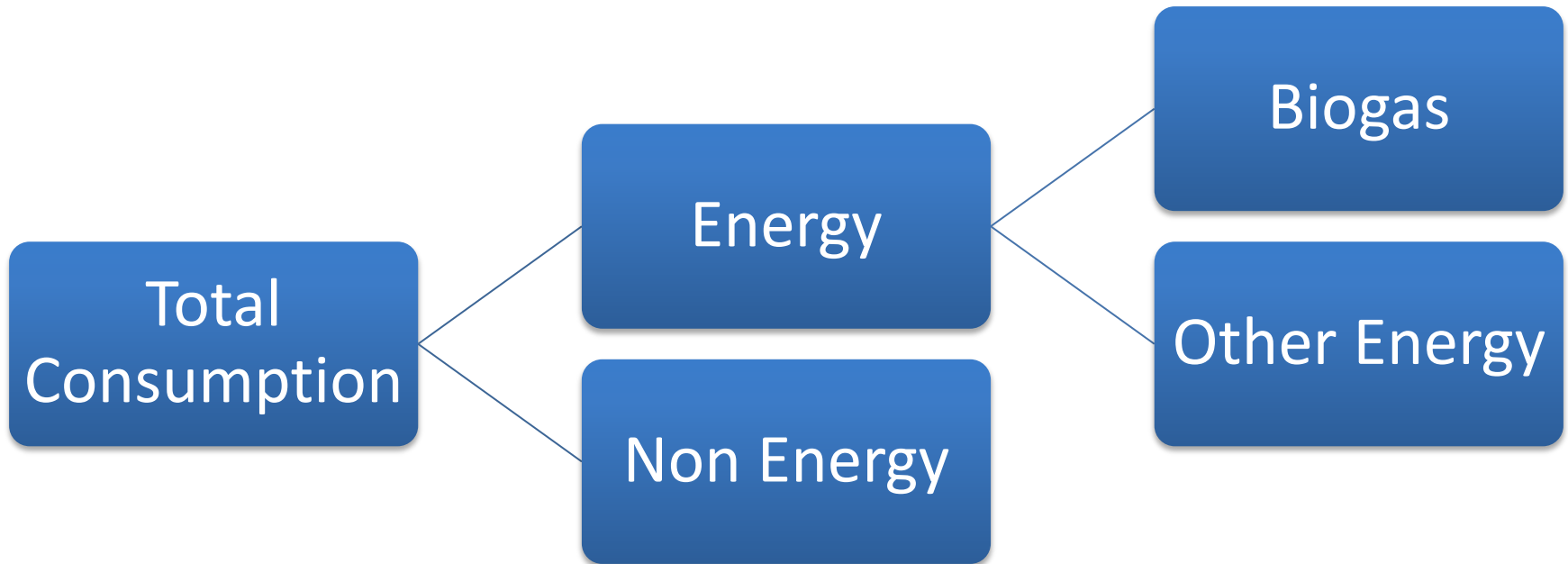
The AMOS model

- 25 sectors model. Imperfect substitutions between domestic and imported goods.
- Three factors of production: Capital, Labour and Land.
 - Fixed population
 - Fixed Land (Algae)
- Government expenditure is fixed in real term.
- Wage determination: real wage bargaining

Production Structure



Households' Consumption Structure



Shocking the model

- The commercial viability of AD plant:
 - Price of seaweed needs to be between £28 and £80 per tonne of seaweed (dry)
- The calibrated price in the model is assumed to be £98 per tonne of seaweed
- Simulations
 - Price of seaweed is reduced via 50% price subsidy (£49/tonne).
- Three scenarios:
 - No Learning
 - Learning (Hicks neutral) on Algae and AD sectors: $A_t = \bar{A} \cdot Y_{t-1}^p$
 - Cumulative learning (Hicks neutral) on Algae and AD sectors :
 $\dot{A}_t = A_{t-1} \cdot Y_{t-1}^p$

Impact of a 50% reduction on the price of seaweed

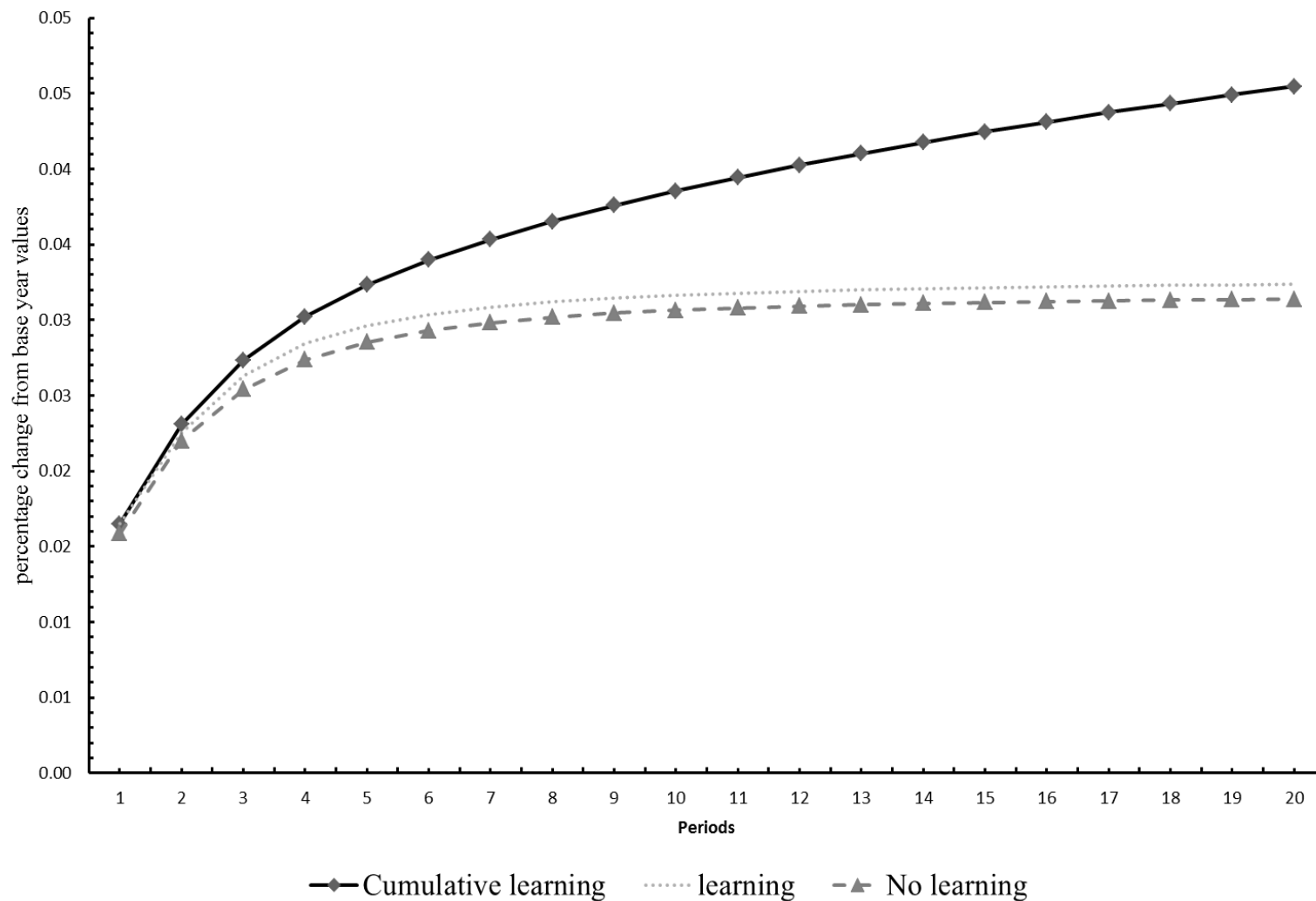


-percentage change from base year values-

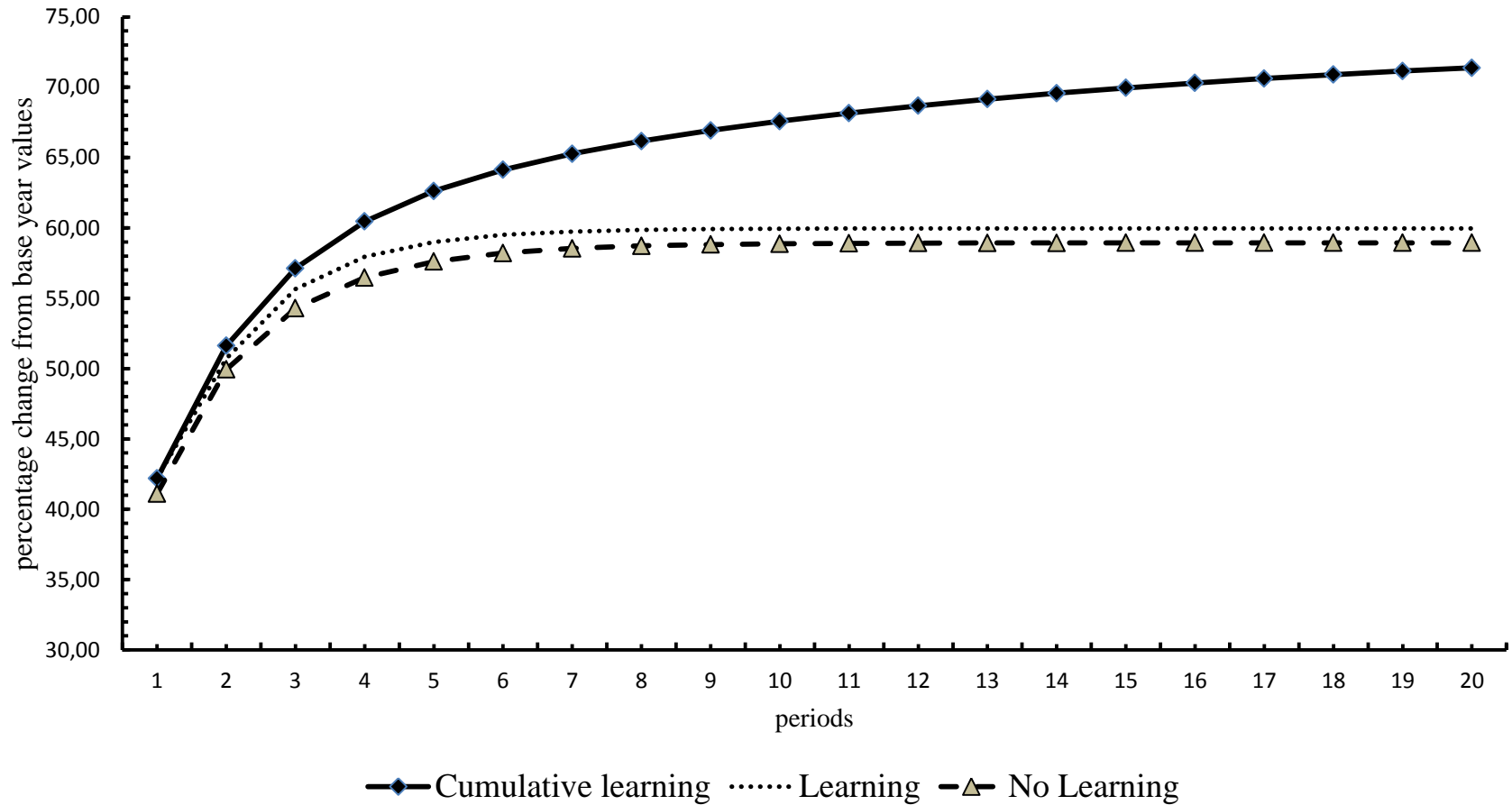
	Short-run	Long-run
GRP	0.016	0.032
CPI	-0.012	-0.026
Unemployment-Rate	-0.081	-0.116
Employment	0.020	0.029
Nominal-Gross-Wage	-0.002	-0.012
Real-Gross-Wage	0.009	0.013
Replacment-cost-of-capital	0.001	-0.003
Labour-supply	0.000	0.000
Households-Consumption	0.052	0.038
Investment	0.124	0.055
Capital-Stock	0.000	0.055
Export-RUK	-0.004	0.013
Export-ROW	0.000	0.011
Rate of return land	147.182	199.197

	Algae		Anaerobic Digestion	
	Short-run	Long-run	Short-run	Long-run
Employment	31.19	38.93	17.65	29.70
Capital stock	0.00	38.92	0.00	29.69
Value added	6.65	23.40	6.12	29.69
Total output	41.10	58.94	25.89	47.70
Household consumption	-	-	3.22	5.83
Output price	-21.60	-36.15	-20.26	-35.17
Value added price	99.41	48.42	40.90	-0.01

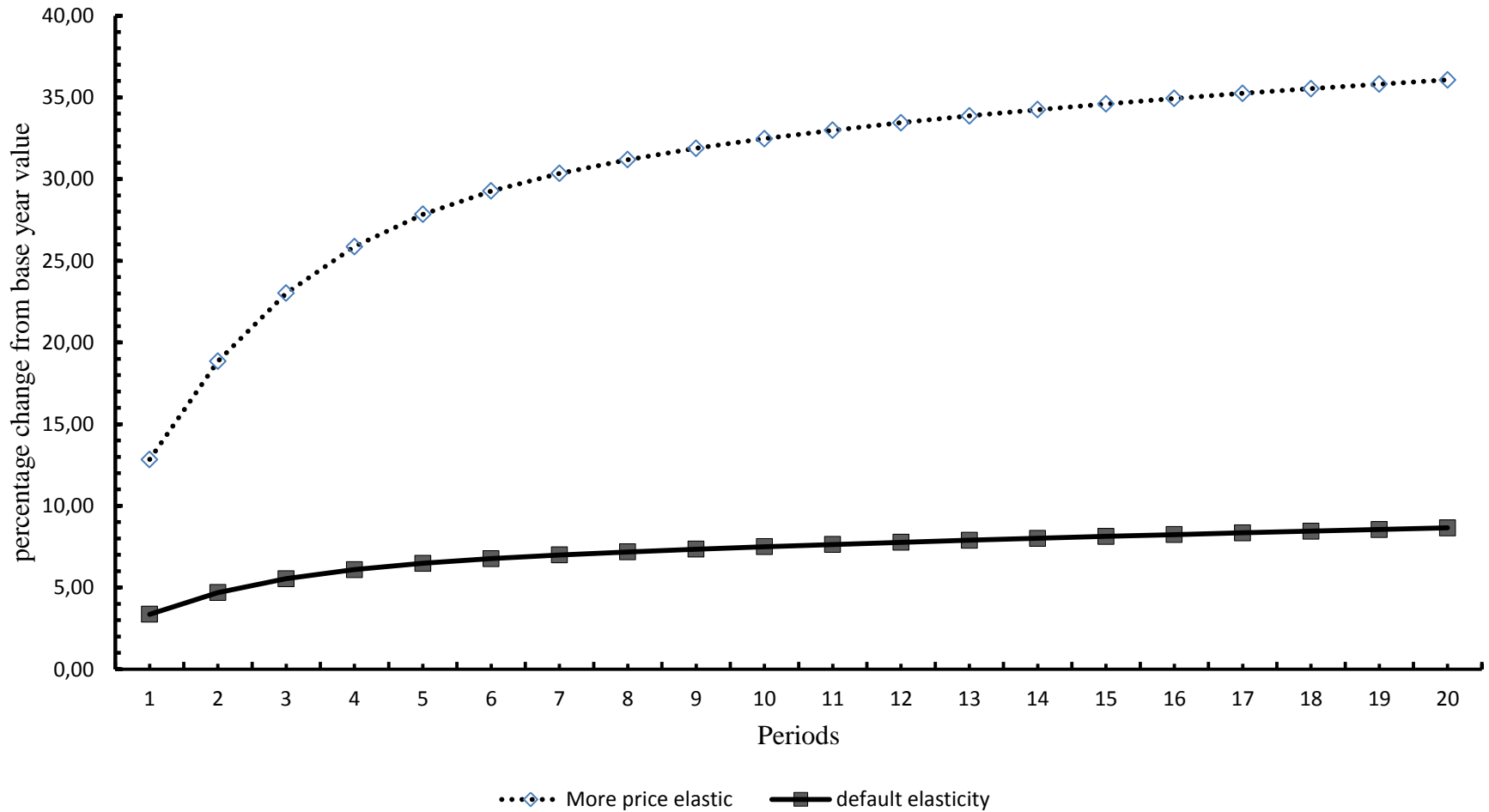
GDP Impact of a 50% reduction on the price of seaweed



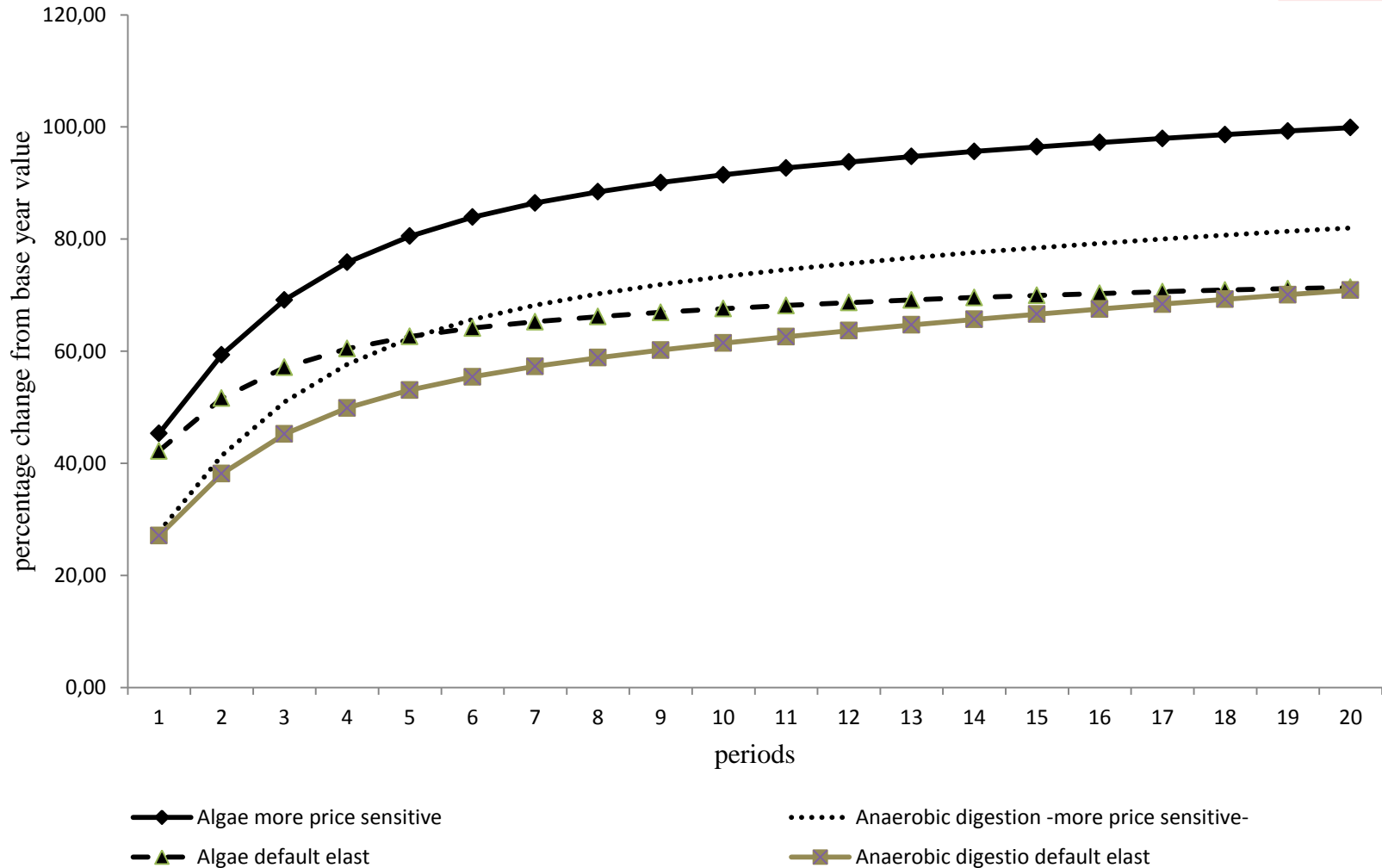
Production of Algae



Consumption of biofuel under different elasticities -cumulative learning-



Production of Algae and Biofuel under different elasticities



Conclusions

- Very small system-wide impact
- Results critically depends:
 - Type of learning process
 - The parameters determining the extent of the learning process.
 - the elasticity of substitution between types of energy
- Treatment of Land

THANK YOU!



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