Grant Agreement no. 308371
ENV.2012.6.3-2 - Policy Options for a Resource-Efficient Economy

- Collaborative project -

D3.7c
Report about integrated scenario interpretation – Comparison of results

Due date of deliverable: Month 36

Submission date: 30 / 09 / 2015

Start date of project: 1st October 2012 Duration: 42 months

Lead beneficiary for this deliverable: GWS

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The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 308371.

Dissemination Level		
PU	Public	X

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1. Introduction

The overall goal of WP3 was to analyse the impacts of policies directed at resource efficiency (industrial and environmental policies) and of behavioural changes based on intrinsic motivation, on the economy, society and environment using a two-way linked modelling approach of three systems: two EE-MRIO models (GINFORS and EXIOMOD) that have both been linked with the biophysical model LPJmL (see Deliverables 3.1 to 3.4). But in contrast to many other model applications the questions to be answered must be seen less in the analysis of the impacts of single policy instruments (with an open result with regard to target achievement) than in the analysis of the strength of policy interventions and intrinsic behavioural changes that are needed to achieve the POLFREE targets (see Deliverable 2.2) under three different governance schemes: *Global Cooperation*, *EU Goes Ahead* and *Civil Society Leads*. A strong foundation for this exercise has been provided by the POLFREE work on "policy mixes for resource efficiency" (see Deliverable 2.3) as well as on "scenario formulation" (see Deliverable 3.5).

Given this rather complex aim of the WP the paper at hand tries to summarise the main differences and similarities of results between the GINFORS/LPJmL and the EXIOMOD/LPJmL scenario exercises. Detailed results as well as model descriptions can be found in the reports on scenario interpretation (for GINFORS/LPJmL in Deliverable 3.7a and for EXIOMOD/LPJmL in Deliverable 3.7b).

The differences of results for the economic and environmental impacts of policies under the three different governance schemes (see chapter three) can be explained by three circumstances:

- The diverging **modelling principles** of a CGE based model, using to a large extent literature based parametrisations (EXIOMOD) and a Neo-Keynesian model, using econometrically based parametrisations. The differences in the theoretical foundation of the two EE-MRIO models are discussed in more detail in Meyer et al. 2015.
- In addition the different modelling principles in combination with the computational background also lead to diverging **ways to implement the policy** mixes in the both model systems, although the policy assumptions have been harmonized to a large extent.
- Last but not least, as will be shown in chapter two, the **reference scenarios** of the both systems are different.

The comparison starts with results for the Reference Scenarios in the two systems. Afterwards the results for the three target scenarios *Global Cooperation*, *EU Goes Ahead* and *Civil Society Leads* are compared. In each case the comparison deals with aggregated figures for the main economic and environmental indicators for EU27 only. More detailed results (i.e. for single countries within the EU27 as well as for countries/regions outside the EU) can be found in the separated reports on scenario interpretation.

2. The Reference Scenario

In the case of GINFORS the *Reference Scenario* assumes globally the policy behaviour business-as-usual, which means for the EU the already implemented or agreed on climate policy and no progressing activities to reduce material extractions and for the Non-EU countries to carry on as usual.

Compared to SSP scenarios the endogenously estimated economic growth in the GINFORS simulation is a bit lower. One reason is the resource prices development: Exogenous prices for fossil fuels (taken from the IEA ETP 6 degrees scenario) and for ores rise strongly. Further the endogenous prices for crops rise even stronger than that of fossil fuels: World population rises till 2050 by one third, economic growth in developing and emerging economies also drives food demand, and land for agricultural use as well as land productivity cannot be extended without bounds. Since price elasticities for food are low, the nominal consumption shares for food rise and reduce demand for other products. A second reason for a bit lower growth rates is the assumption of budget constraints in case of a rise of the public debt ratio. This seems to be necessary to get more realistic scenarios, which otherwise could not exclude the creation of a financial crisis.

In the case of EXIOMOD the *Reference Scenario* is calibrated on the CEPII EconMap v2.2 data (Fouré et al., 2012; Fouré et al., 2013). From this database the projections for capital stock, labour supply and trends in capital-labour productivity and energy productivity have been taken. The resulting GDP values from EXIOMOD are higher than the GDP values in the CEPII data. This is caused by a different definition of the production function as well as by the price and substitution effects of the CGE model that are not mentioned in the approach used by CEPII. EXIOMOD has been constrained to converge to the CEPII GDP scenarios by adjusting the capital productivity and capital stock.

In the EXIOMOD Reference Scenario GDP of EU27 is growing over the period 2015 to 2050 with an average annual growth rate of 1.4 %, whereas this rate for the GINFORS Reference Scenario is just 0.9 %. This means that EXIOMOD for the year 2050 expects about 20 % higher GDP of EU27 than GINFORS, but at the same time CO2 emissions are in EXIOMOD about 20 % lower than in GINFORS (see table 1). This means that the exogenously in EXIOMOD implemented efficiency trends are much stronger than the endogenously working determinants of GINFORS. A look at the GDP components indicates that in the case of GINFORS positive contributions to growth are especially coming from the global competitiveness of the European industries whereas in EXIOMOD the total opposite can be observed: the external balance reduces growth and main contributions are coming from private and public consumption.

Unfortunately a direct comparison of results for the developments on the labour markets is not possible. The Reference Scenario of GINFORS predicts for EU27 a reduction of the number of persons engaged down to 185.7 million in 2050. At the same time the (exogenously given) population in the age group of 15 to 64 years is expected to reduce to 187.2 million people. This means that in the GINFORS *Reference Scenario* a (slightly) increasing unemployment problem in Europe is predicted. In contrast to this in the CGE-based model EXIOMOD unemployment per definition does not exist. Regarding population growth, the CEPII projections which EXIOMOD uses are based on the UN population projections (medium fertility variant), same source as used by GINFORS.

With regard to the environmental pressure indicator RMC the comparison shows differences: The GINFORS results for $RMC_{abiotic}$ start in 2010 with a per capita value that is about 20% lower than the one of EXIOMOD and the predicted reduction up to 2050 in EXIOMOD is much stronger than in GINFORS. Background for the different levels in 2010 might be founded in the different historical databases of the two systems as well as in the algorithms/concepts to calculate imports and exports in raw material equivalents. If we compare these values with the respective EUROSTAT values for 2009 (= 12.1 tons) it can be seen, that GINFORS predicts only a slight increase in the year after crisis, whilst EXIOMOD predicts an increase above the pre-crisis value (14.2 tons in 2008).

The results of the GINFORS *Reference Scenario* show a rather weak increase of raw material productivity ($GDP/RMI_{abiotic}$) up to 2050 (33,5% within 40 years) that is far away from anything like a factor 4 and a clear sign for a need of change. The raw material productivity resulting from EXIOMOD amounts to 1.65 euro per kg in 2010 and 3.32 euro per kg in 2050, implying an improvement of over 100% within 40 years.

The next topic that should be mentioned with regard to the *Reference Scenario* is the big difference between the two systems for the average domestic crop production prices. In GINFORS/LPJmL the predicted global demand for crops is growing faster than the crop yields (and the global crop land). Background for this (endogenously explained) development is not only the increase of world population but also an increasing demand for feed and processing purposes. This leads to a steep increase of crop prices on the world market and the (empirically validated) assumption in GINFORS is, that the domestic crop production prices within the EU react on these global developments. In contrast to this EXIOMOD assumes no additional land scarcity in the form of crop prices. The demand for crop land simply reflects the demand for crops and yield improvements but does not include any land boundary (this is only the case in the policy scenarios). In the Reference Scenario of EXIOMOD/LPJmL the global land use for crop production rises from 1.4 bln ha in 2010 to 2.9 bln ha in 2050. This means an average yearly growth rate of 1.8% or a doubling within less than 40 years, values that by far exceed historical observations.

A comparably big difference between the two systems concerns the results for water use, although for this topic the comparison is biased by different concepts: Whilst the GINFORS/LPJmL system deals with the abstraction of (blue) water the EXIOMOD/LPJmL systems reports about blue and green water use. Given these differences the GINFORS/LPJmL reference scenario expects only a very moderate increase in global water abstraction in the period 2010 to 2050 (per capita abstraction -24%; population +38%). On the other hand the EXIOMOD/LPJmL reference scenario expects a dramatic increase in global blue and green water use per capita of 100% up to 2050. Together with population growth this means tripling. This again hints at fundamental discrepancy between the two reference scenarios. Whilst in GINFORS already in the reference the global use of resources is restrained due to natural and societal boundaries, in EXIOMOD this only holds for the transition scenarios.

Table 1: Main aggregates – comparison of results for the Reference Scenario.

Indicator		Dimension	GINFORS/LPJmL		EXIOMOD/LPJmL	
			2010	2050	2010	2050
EU27 Economic Performance (in constant prices)						
EU27 GDP		2010=100	100	141.6	100	172.4
EU27 Household Consumption		2010=100	100	115.2	100	182.4
EU27 Public Consumption		2010=100	100	130.0	100	180.3
EU27 Investments		2010=100	100	157.7	100	168.5
EU27 Exports		2010=100	100	265.6	100	209.0
EU27 Imports		2010=100	100	209.9	100	271.4
EU27 Social Development						
EU27 Employment		in mio.	223.5	185.7	n.a.	n.a.
Environmental pressure						
CO2 emissions	World	in Gt	29.4	44.8	33.7	46.8
	EU27	in Gt	3.98	2.93	3.89	2.36
EU27 RMC per capita		in t	n.a.	n.a.	19.2	15.8
$RMC_{abiotic}$ per capita	World	in t	6.8	9.1	7.0	7.5
	EU27	in t	12.2	11.8	15.0	12.6
EU27 Resource Productivity ($GDP/RMI_{abiotic}$)		2010=100	100	133.5	100	201.2
Ecosystem services						
Water abstraction	Global per capita value	in m^3	251	191	n.a.	n.a.
Blue and green water use		in m^3	n.a.	Na	1130	2250
EU27 average Water Exploitation Index		in %	10	12	11	15
EU27 average Domestic Crop Production Price		2010=100	100	317.7	100	107
Crop Land	World	in bln ha	1.44	1.55	1.40	2.88
	EU27 Footprint per capita	in ha	0.31	0.27	n.a.	n.a.

3. The results for the transition scenarios

The modelling exercise on transition scenarios towards a resource efficient Europe in 2050 was not only carried out for one scenario, but for three pathways that reflect different governance schemes and narratives. The scenario *Global Cooperation* as well as the scenario *EU Goes Ahead* follows more or less a green growth storyline. The main policy interventions are intended to getting prices right and to increase resource and energy efficiency of production processes. Whilst the *Global Cooperation* scenario assumes a high global willingness to cooperate, the *EU Goes Ahead* scenario addresses the question on the impacts of a pioneer role of the EU countries. On contrary the *Civil Society Leads* scenario assumes that major changes will come from the EU citizens (consumers) themselves that more and more change their habits and attitudes towards sustainable lifestyles. Of course these three different transition scenarios have to been seen as a theoretical exercise to analyse the different impacts and not as competing hypothesis. The most realistic (and preferable) scenario would certainly be one that contains elements of all three of them.

But what kind of policy measures are we talking about? To answer this question we refer to the profound research work that has been carried out by Wuppertal Institute (see Deliverable 2.3). On base of this research and in-depth discussions within the whole POLFREE consortium it was possible to specify a set of more than 30 single policy measures and behavioural changes

- that are already used/observable or at least discussed to improve resource efficiency and
- for each of them it is assured that the consideration of the environmental and economic impacts within the both systems is possible.

For each of this specified policy measure it has been discussed and decided whether they are to be considered in all or only in a certain transition scenario and whether they are to be considered to which extent globally and in EU27 countries.

Where ever necessary direct impacts of policy measures and/or realistic assumptions about the extent of behavioural/technical changes have been identified based on literature research to avoid the danger that the (environmental) problems are simply assumed away.

Impacts on the environment

In this chapter we look at the results of the two systems for the main environmental indicators. The question at hand that should be answered by this exercise is: Seems a simultaneous achievement of the environmental POLFREE targets for the EU up to 2050 possible, if an extended mix of different policy measures will be used?

Table 2 summarizes the main results for carbon, raw materials, water and land. The first clear message of the results of GINFORS/LPJmL is that a simultaneous achievement of the environmental headline targets is possible, maybe with one exception: the non-metallic mineral part of RMC. But of course, as can be learned from the detailed results and assumptions about policy measures documented in D3.7a, ambitious action from policy, industry and citizens is needed. Besides this the simulation results of GINFORS/LPJmL for many cases show no perfect alignment with the target. But this should not be interpreted as an impossibility to achieve the

target. Minor deviations are rather justified by the need to concentrate on the most important policy measures.

Table 2: Comparison of results for the Transition Scenarios – the environment

Results for 2050		GINFORS/LPJmL			EXIOMOD/LPJmL		
		Global Coop.	EU Goes Ahead	Civil Society Leads	Global Coop.	EU Goes Ahead	Civil Society Leads
Carbon		Target for EU27: CO2 emissions < 1 Gt (reduction of > 80% compared to 1990)					
CO2 emissions	World	17.9 Gt	32.7 Gt	31.3 Gt	33.8 Gt	36.4 Gt	35.2 Gt
	EU27	1.3 Gt	1.1 Gt	1.2 Gt	1.2 Gt	1.2 Gt	1.1 Gt
Raw Material		Target: RMC per capita < 5 tons; Target for Resource Productivity not mentioned					
$RMC_{abiotic}$ per capita	World	3.9 tons	8.7 tons	8.5 tons	2.9 tons	2.9 tons	2.9 tons
	EU27	4.4 tons	5.6 tons	6.9 tons	5.3 tons	5.4 tons	5.3 tons
$GDP/RMI_{abiotic}$ (2010=100)		389.4	277.9	167.5	n.a.		
Water		Targets: Global water footprint per capita < 70% compared to 2004 (2004 values: ~ 260 m^3 water abstraction; ~ 1100 m^3 blue and green water use); Water exploitation index < 20%					
Water abstraction	Global per capita value	166 m^3	191 m^3	191 m^3	n.a.	n.a.	n.a.
Blue and green use		n.a.	n.a.	n.a,	2065 m^3	2377 m^3	2028 m^3
EU27 Average Water Exploitation index		9.6%	9.4%	9.0%	13%	13%	12%
Land		Targets: Global crop land use per capita < 66% compared to 2005 (2005 values: ~ 0.22 ha global; ~ 0.35 ha EU27 Crop Land Footprint)					
Global crop land use per capita (in ha)		0.15	0.16	0.15	0.24	0.27	0.22
EU27 Crop Land Footprint per capita (in ha)		0.27	0.25	0.16	n.a.	n.a.	n.a.

For EXIOMOD/LPJmL in order to reach all targets simultaneously additional assumptions had to be made with regards to technological progress or resource efficiency improvement in the range of 0.4-1.5% annual productivity improvement (crop yield 0.4%; material productivity 0.7% and energy efficiency 1.5%). This means that the policy mixes and intrinsically motivated behavioural changes alone do not allow target achievement.

If we go a little bit more into detail the comparison of results gives some more interesting insights:

Carbon: With regard to CO2 emissions of EU27 the result neither between the two systems nor between the transition pathways differs substantially. The highest deviation can be found between the *Global Cooperation* and the *EU Goes Ahead* Scenario in GINFORS/LPJmL. The appropriate interpretation is that the lower prices for fossil fuels in the *Global Cooperation* scenario make it more difficult for the EU27 to reach the target.

The main difference between the two systems concerns the global CO2 emissions. Although in the scenario *Global Cooperation* it is assumed that not only in the EU27 but all around the world an ambitious climate policy is in charge, for EXIOMOD/LPJmL these assumptions/policy measures outside the EU seem not to be capable to reduce CO_2 emissions down to a level that assures the compliance with global warming below 2 degrees. And this difference cannot be explained by differences in the reference scenarios. Although both systems expect differences in growth they generate more or less the same pathways for global CO_2 emissions in the reference scenarios.

Raw Material: The main accordance of the results of the two systems is that a perfect alignment to the policy goal (RMC per capita < 5 tons) seems more difficult to achieve than for the emissions target. And the both systems also agree on the result that these difficulties are especially valid for the non-metallic minerals.

The main difference of the results between the two systems is that in the GINFORS scenarios noticeable differences between the three transition pathways emerge, whilst this is not the case for EXIOMOD. This can be explained by the fact that the assumptions regarding material use are similar across scenarios in EXIOMOD. Recycling quota is implemented globally in all scenarios. In scenario 1 and 2 there is an extraction tax/RMC based tax while in scenario 3 there is autonomous reduction of harmful goods, which is modelled in the same way as extraction tax/RMC based tax due to computational reasons[1].

The GINFORS/LPJmL system comes to the conclusion that global cooperation is the most appropriate way to succeed. In the *Europe Goes Ahead* scenario target achievement gets more difficult in a globalized world in which final and intermediate goods (that are demanded within the EU27) are globally produced with less raw material productivity improvements than within Europe. Even more complicated it gets in a pure *Civil Society Leads* scenario, if the behavioural changes based on intrinsic motivation only/mainly happen within Europe (as it is assumed in the scenario experiment) and the European industries, that produce (and invest) to satisfy the global demand do not succeed in further resource productivity improvements.

[1] The harmful commodities need to be identified in scenario 3 where autonomously harmful commodities are consumed less. The set of harmful commodities change due to the policy measures in the scenarios (e.g. electricity becomes less harmful over time) and we therefore did not identify a priori a fixed set of harmful commodities. Instead in EXIOMOD an increased price for resources at the source of extraction (e.g. fossil fuels) has been modelled, leading to reduced consumption of harmful commodities depending on each scenario and each year.

Water: With regard to water both systems share the expectation, that the compliance of an water exploitation below 20% in all EU27 countries is possible. But besides this big differences in the results are obvious. We can see that for the GINFORS/LPJmL system the transition scenarios stay within the planetary boundaries of water abstraction whilst this is not the fact for the EXIOMOD/LPJmL system, where global per capita water use in 2050 – although by 4% [*EU goes ahead*] to 18% [*Civil Society Leads*] lower than in the Reference – still is by 70-100% higher than in 2004 (and not more than 30% lower as the target states).

Land: For the land issue the transition scenarios of GINFORS/LPJmL expect more or less an alignment of the targets, if the explored policy measures and behavioural changes would become operative. But for the *Global Governance* scenario as well as for *EU Goes Ahead* scenario the EU per capita footprints do not perfectly reach the reduction wanted. This hints at the importance of consumers and their habits (meat consumption, food waste, etc.) in this nexus.

For the EXIOMOD/LPJmL the results again are different. On the one hand this system does not report about the crop land footprints of EU27. For the global values the same holds as for the water topic: although the global crop land per capita in the transition scenarios is lower than in the reference (-33% in the *Civil Society Leads* scenario to -18% in the *EU Goes Ahead* scenario) they by far exceed the targeted value of around 0.15 ha. These high land use values can be interpreted as upper boundaries because the current setup of EXIOMOD/LPJmL models did not take explicitly into account the closing of the yield gap (less productive farmers catch up and become more productive in the future). This potential closing of the yield gap could significantly reduce the demand for land in the future.

Impacts on the economy

In the *Global Cooperatio*n scenario of GINFORS/LPJmL the induced investments in new technologies – especially in the energy field - create economic growth and more jobs globally as well as in the EU. In the EU investment rises by 17 % against the reference and GDP, is in 2050 about 8 % higher than in the reference (see table 3). Employment exceeds in 2050 the number of the reference with about 1.5 million persons, which means that the employment quota rises from 64.6% to 65.2%. The taxes and regulations for resource use reduce emissions and extractions of resources, which allow reaching the targets. This is supported by a change of relative prices in consumption: resource intensive products are substituted.

A very similar scenario has been assumed in the simulation with the model EXIOMOD. Of course the tax rates etc. are not the same due to different model structures. The main difference concerns the compensation of the tax revenue, which in the case of EXIOMOD has been given to the households and the firms via reductions of social security contributions.

Meyer et al. 2015 argue that the direct economic effects induced by taxation and regulation of inputs will be very similar in a neoclassical and a CGE model. The only critical point that the tax revenue might create public savings, which in EXIOMOD, but not in GINFORS would affect investment, is not given because the tax revenue is payed back to the economy. But the induced investment especially for renewables in electricity production and for the renovation of buildings

has no positive effect on the total investment of the EU economy (-2.1%), whereas in the GINFORS case a rise of this figure of 17 % could be recognized. In EXIOMOD the neoclassical assumption of a determination of investment by savings is responsible for this result: Because no additional savings are created by the policy mix, total investment can't expand and the induced investments in renewables and buildings suppress the investments of other sectors. In the GINFORS simulation the additional investment induces a multiplier/accelerator process creating an 8 % higher GDP, whereas in the case of EXIOMOD a small reduction of GDP is the result.

Table 3: Comparison of results for the Transition Scenarios – the economic impacts

EU27 results - deviations from the reference scenario in 2050	GINFORS/LPJmL			EXIOMOD/LPJmL		
	Global Coop.	EU Goes Ahead	Civil Society Leads	Global Coop.	EU Goes Ahead	Civil Society Leads
Economic performance (in constant prices)						
GDP	+ 7.9%	+ 12.2 %	-21.5%	- 0.6%	- 0.3%	- 12.1%
Household consumption	+ 3.2%	+ 7.5 %	-38.9%	+ 1.1%	+ 0.9%	- 25.9%
Public consumption	+ 8.7%	+ 9.2 %	-18.7%	- 2.1%	- 0.9%	- 16.0%
Investments	+ 17.0%	+ 6.4 %	-24.9%	- 1.3%	- 1.6%	+ 31.9%
Exports	+ 6.2%	+ 10.3 %	+2.4%	- 0.3%	+ 2.2%	- 4.6%
Imports	+ 5.4%	- 2.2 %	- 25.6%	+ 2.0%	+ 5.7%	- 0.4%
Social development						
Employment	+ 0.8%	+ 1.8 %	+ 9.3%	n.a.		

In *EU Goes Ahead* scenario the EU27 countries introduce primarily economic instruments in addition to regulations. The design especially of tax instruments is essential to avoid problems with international competitiveness: The first and simple approach is to tax only industries which are not in international competition. If an industry is supplying on international markets and it is charged by an environmentally motivated tax it is useful to compensate this industry directly with the tax revenue, but to use for the allocation of the money to the firms a neutral key like gross production. The incentives for a structural change are high, because the charge rises the higher the damage of the environment by the firm is, whereas the subsidy is higher the better the environmental performance of the firm in question is. On an average industry level a cost neutral result can be expected. A third strategy in the design of taxation is to tax only final demand with the exclusion of exports. In this case imports of the good in question are taxed with the same rate as sales from domestic production. Since all taxes are as far as possible directly compensated the European industries should have no problems with their international competitiveness.

But how does this fit with the GINFORS/LPJmL result that the deviation of total investment demand from the reference shrinks from 17 % in scenario *Global Cooperation* to 6.5 % in *EU Goes Ahead*? The reason is that the RMC based tax on final demand especially hits investment demand. But this effect hits not only domestic production, but also imports, so that total imports deviation from the reference shrinks from 5.4 % to -2.3 %. For the EU the First Mover Advantage

of lower resource costs is able to raise the deviation of exports to the reference from 6.2 % in *Global Cooperation* to 10.3 % in *EU Goes Ahead*. In total GDP is 12.3 % higher than in the reference.

The EXIOMOD/LPJmL simulations of the scenario *EU Goes Ahead* show more or less the same economic impacts for the EU27 as the *Global Cooperation* scenario. Especially the positive effect of tax recycling in the form of labour cost reductions are noticeable for households in scenario 1 and 2. Due to this tax recycling demand for labour goes up resulting in higher wages and also reduced labour taxes lead to higher disposable household income. The negative effect on investment demand from the RMC based tax cannot be identified in table 3, because in the neoclassical context total investment demand is determined by stable savings, which means that these reductions are compensated by the rise of other investment activities. The deviation of exports from the reference improves compared with scenario 1 (*Global Cooperation*), but not as strong as in the GINFORS simulation.

The scenario *Civil Society Leads* assumes that instead of taxes and regulations intrinsic motivation of consumers and employees is the main driver for structural change of the economy. It is assumed that several activities change the structure of consumption reducing demand for environmentally harmful commodities like consumer durables or meat. Further employees want to reduce the hours worked having a higher share of part time jobs to have more time for the family, engagement in society and leisure. In a last step the level of total consumption has been reduced.

In the GINFORS/LPJmL case the assumed behavioural changes lead to a fall back of per capita consumption levels to 1995 values. Exports remain more or less at the level of the reference because they depend on the international competitiveness of the EU industries and the economic development abroad, which both are not significantly affected by changes of consumer behaviour in the EU. But the changes induce a negative multiplier/accelerator process decreasing private consumption by 38.9 %, public consumption by 18.6 % (reduced tax revenue) and investment by 25 % against the reference. International trade is a stabilizing factor: Exports rise slightly by 2.5 % and imports fall because of reduced consumption by 25.6 %. GDP is in 2050 21.4 % lower than in the reference, which means zero growth from today to 2050. The assumed reduction of hours worked is 20 % which is just the endogenous reduction of GDP against the reference. This does not mean that the number of persons engaged is the same as in the reference, because the real wage rate is much lower than in the reference due to lower labour productivity development. The Scenario *Civil Society Leads* has by far the highest employment figures of all scenarios: In 2050 in the EU 17 million more persons are employed. This fits with the preferences of Civil Society of this scenario whereas the lower GDP will not be counted in this “Beyond GDP” world.

The EXIOMOD simulations for the *Civil Society Leads* transition pathway show quite different results: First the necessary reduction of total consumption is with 25.9 % much lower than in the GINFORS case. This can partly be explained by different assumptions concerning structural change in consumption. In the EXIOMOD simulations it is assumed that households will work 20% hours less as well as save 15% more of their income. This should then result in 35% less total consumption but due to CGE effects the actual reduction is 25.9%. In the EXIOMOD simulation investment rises by 31.9% against the reference, whereas in the GINFORS case a decrease of 25% has been indicated. The reason for this discrepancy is once more the different modelling of the capital market. In EXIOMOD savings are the determinant of investment, and savings rise

drastically, because consumption falls. In GINFORS investment is related to production in an accelerator approach. In EXIOMOD investment stabilizes the economy so that the deviation of GDP from the reference in 2050 is only -12.1%, which allows for a path with a slightly reduced growth rate.

4. Conclusions

The CO_2 target for the EU is met more or less with both models in all alternative scenarios. But the global target in scenario Global Cooperation, which assumes an ambitious climate policy globally, is only met in the GINFORS simulation, whereas EXIOMOD calculates for this scenario emissions of the range of the other scenarios which assume only a moderate climate policy for the Non EU countries. Concerning RMC both models are near to the EU targets (exception: GINFORS in Civil Society Leads). The global target in scenario Global Cooperation is fulfilled by both models. In the case of the other transition scenarios there is no specific policy assumed outside the EU. Here GINFORS calculates higher global RMC numbers than in Global Cooperation, whereas EXIOMOD has the same RMC results in all scenarios due to the same assumptions in all scenarios.

The cropland target is met in the GINFORS simulations. EXIOMOD reaches it cropland target only at the EU level and already in the unconstrained reference scenario a very strong extension of global cropland use is given. GINFORS assumes in the reference that the year by year extensions of cropland due to rising demand have limits as can be learned by historical observations. This difference between both models induces fundamental discrepancies in price development for crops: In GINFORS simulations the due to the link with LPJmL endogenously explained crop prices have the highest growth rates, whereas they are more or less stable in all EXIOMOD scenarios. The target for water exploitation is met by both models in all simulations.

Regarding the target achievement for carbon, raw materials, land and water in the both models it can be summarized, that in GINFORS endogenous adaptation processes that are induced by the policy mixes more or less lead to the targeted values. The biggest problem that has been observed, and not assumed away, regards the possibilities to decrease the use of non-metallic minerals down to one third of nowadays values. On the other hand EXIOMOD calculates target alignments on EU27 level but this only by introducing additional assumptions on resource productivity.

Summarizing the economic results we have to see that in all simulations the macroeconomic results of the application of EXIOMOD and GINFORS have been very different. Of course all three market imperfections – labour market, goods market and capital market – are responsible for that result as Meyer et al. 2015 show.

But the different modelling of the capital market creates the strongest discrepancies in results: The CGE model assumes that every saving – from whom it ever may come – is supplied on the capital market and it will be taken from the investors however the further economic conditions are. Capros et al. (1990) claim, that this is necessary to close the model. But this is not true. Also the Neo-Keynesian model with its independent investment functions finds a solution which implies the equality of investment and savings, but of course at other income levels than in the CGE case. Also the comment (Capros et al. 1990, p. 575) that the Neo-Keynesian model is biased, if the

gains in public account have no feedback on the capital market can only be understood from the neoclassical understanding of a perfect capital market. To say it once more: The equality of savings and investment does not necessarily mean that the savings determine investment. Both are depending from different variables, but the solution of the model includes their equality.

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