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Imperfect Markets and the Properties of Macro-Economic-Environmental Models as Tools for Policy Evaluation

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TABLE OF CONTENTS

1 INTRODUCTION

The dependency of emissions and extractions of resources from the economic development can only be understood on the basis of models with a deep industry and/or product-specific disaggregation of the economy, which allows identifying the environmentally important consumption, investment and production activities in their relation to the entire economy. So input-output modelling is essential for environmental studies. But the open static Leontief model is too simple. A system is needed which has all this and in addition endogenizes final demand and factor demand for labour and capital. As every textbook on input-output economics shows, these extensions have all been done, but these models describe a linear world with constant input coefficients and constant consumption and investment ratios, in which prices and volumes are independent from each other. How to implement economically acting agents in such a framework?

Johansen (1960) gave the answer in the neoclassical tradition: He developed a model, in which households maximize their utility subject to their budget constraint. Industries decide on inputs minimizing costs subject to production function constraints. Investors allocate capital to industries to maximize their profits. This model is the first in the long tradition of CGE modelling. Almon (1967) was the first to integrate the input-output approach in a macro-econometric (ME) framework based on Keynesian theory.

Both types of disaggregated macroeconomic models have been used in the last 50 years for the evaluation of policies in complex application fields relating to economic-environmental questions. The models used in economic-environmental applications became huge, because the questions to be answered need a global, but also a deep country, sector, resource and pollutant perspective with all its interrelations. The systems are called 3E models because they show the interdependences between the Economy, Energy and the Environment. This allows using them for policy assessment. The central question is what impact a policy has on sustainability which means that economic, social and environmental indicators have to be explained by the models. Examples are the CGE model IMAGE (Fontagne 2013) and the Neokeynesian model GINFORS (Meyer et al. 2015).

The broad acceptance of neoclassical theory allowed to make assumptions on central elasticities and to calibrate the rest of the parameters of the models on the basis of one data point. This easy method of parameterization became more or less standard. Only several CGE authors like Jorgenson - one early example is Hudson and Jorgenson 1974 – prefer the econometric parameterization. Jorgenson (1984) gives a detailed analysis of the advantages of econometric parameterization for CGE models. In the case of Neokeynesian models the modelling of bounded rationality and imperfect markets is much more open than that of perfect competition. Therefore the behavioural equations of these models have to be estimated econometrically, which is, of course, arduous, but gives the model an empirical underpinning.

The big success of the neoclassical revolution in the 70s and 80s pushed the development of CGE models. Today CGE models are the typical “work horses” of economic-environmental studies. Böhringer and Löschel (2006) give an overview of the state of art. They show

that the main representatives of this class fulfil all requirements relating to economic indicators, but have deficits in regard to environmental and social indicators, which can be reduced linking the models to specific natural science and social models. The same experience has been made in the application of the Neokeynesian model GINFORS that has been linked to the vegetation model LPJmL (Beringer et al. 2011) and the material model WORLD (Sverdrup et al. 2012).

The paper at hand is not a critical assessment of both types of models. This work has been done – concerning CGE models – by Grassini (2007), Serban Scrieciu (2007), and others. We are interested in the question which influence the central assumption about the market structure has on the properties of the models when they are used as instruments for policy assessment. What does it mean – all other structures equal – for the economic results of policy simulations whether a model assumes perfect or imperfect markets? Furthermore, we want to know which effects are combined with the different methods of parameterization.

The neoclassical paradigm is clear: All agents act on perfect markets, producers maximize their profits facing a substitutional production function, and consumers maximize their utility constrained by income. But what is the theoretical base of Neokeynesian modelling and how can it be implemented in deeply disaggregated macro-econometric models?

In chapter 2 we try to give an answer and meet the literature which Dornbusch at al. (2008) qualified as the “Neokeynesian Counter Revolution”. We start with the labour market and discuss approaches of wage determination of Samuelson and Solow (1960), Stiglitz (1976) and Yellen (1984), which explain why the wage rate may be permanently above the market clearing rate. We then proceed to the capital market and discuss first the question whether investment and savings can be either both independent variables or that one of them has to be dependent on the other. Rattsö (1984) stressed the importance of this question for policy evaluation which is discussed in the literature as the “macroeconomic closure” problem. We follow Greenwald and Stiglitz (1987) and their view on imperfections of the capital market. Imperfections of the goods markets have been analysed by Akerloff and Yellen (1985), Stiglitz (1987), Romer (1993) and others. We check the relevance of these approaches for disaggregated macroeconomic modelling.

To find the impacts of market imperfections in the macroeconomic context we follow in chapter 3 an interesting experiment of Capros et al. (1990), which is situated methodologically just in the middle between a pure theoretical analysis and the interpretation of simulation runs of two large scale models. They specified a CGE model and a Neokeynesian model which are identical except the assumptions about the market structures. These models are big enough to cover real world phenomena and on the other side small enough to be analysed without running into complexity problems. These models have been shocked with exogenous variables and the results have been interpreted.

Furthermore, we want to discuss which consequences are associated with the parameterization by assumption for some and calibration of the rest of parameters by one single data point instead of an econometric estimation of parameters. Two points have to be made in this context. The first concerns the plausibility of the reference solution of the model. In chapter 4 we discuss the role of the two different approaches in the construction of the reference.

In chapter 5 the effects of the different methods of parameterization on policy results are discussed. Of course, this can only be done in a concrete model application, but then all three causes are responsible for differences in results that come into consideration simultaneously. We choose the POLFREE project where the two large-scale models EXIOMOD (CGE) and GINFORS (Neokeynesian) have been applied in an economic environmental analysis. Some conclusions in chapter 6 close the paper.

2 MARKET IMPERFECTIONS IN THE MACRO-ECONOMETRIC CONTEXT

A major aim of the project was the development of a web tool that sensitises its users to their own consumption decisions in favour of globally fair and sustainable use of resources. The web tool is more than just a simple calculator. It contains valuable background information about the durable household goods and materials. Furthermore, it gives advice to help users to consume resources more sustainable.

Keynes criticized classical theory indicating that the labour market and the capital market are imperfect. The wage rate has not the flexibility to equilibrate the labour market and the incomplete information of lenders and borrowers of capital does not guarantee that savings determine investment as neoclassical theory claims. With these corrections, Keynes was able to show that equilibrium in the circular flow of income could coexist together with permanent unemployment.

Neokeynesian theory uses micro foundations for these two imperfections and adds stickiness of goods prices so that in this approach, all markets fail to work as neoclassical theory presumes it.

2.1 LABOUR MARKET

To have a model solution that allows for unemployment, it is not necessary to have a sticky wage. A theory is needed that shows that the real wage rate can be permanently above the market clearing rate. A simple explanation for such a situation could be a strong power of unions in the sector and country in question. In the wage bargaining process the expected productivity development of the industry in question and the inflation rate are the arguments to find the nominal wage rate for the contract, which holds for a certain period. This is the Phillips Curve approach in the interpretation of Samuelson and Solow (1960). The resulting real wage rate is not related to the market clearing rate.

Of course, strong unions are not to be found in all industries and countries. What pushes producers to pay voluntarily more than the market clearing rate? The answer is that it must pay for the producers. The efficiency wage theory (Stiglitz 1976) shows that the higher wage rate raises the efforts of employees and reduces labour turnover. Each firm hires employees until the real wage rate equals the marginal productivity of labour. Yellen (1984) gives an overview of several variants of this theory.

2.2 CAPITAL MARKET AND MACROECONOMIC CLOSURE

The neoclassical equilibrium in the labour market determines the real wage rate and fixes labour demand to the level of labour supply. The capital stock is given from the investment of preceding periods and depreciation. With the inputs of labour and capital the output is given by the production function and cannot be influenced from the demand side of the economy. This means that in the neoclassical framework we are not free in modelling demand. Sen (1963) concluded that so called “closure rules” have to be mentioned, if inconsistences between supply and demand shall be avoided. In a closed economy, a rise of consumption has to be accompanied by a fall of investment, which totally compensates the effect on total demand. Total GDP is defined as the sum of consumption and investment. Subtracting from both sides consumption gives the equality of savings and investment. The inconsistency problem can be solved either if investment is determined by savings or if savings are determined by investment. In the first case Sen (1963) speaks of a “neoclassical closure”, in the other case of a “Johansen closure”. In the second case we are still in a neoclassical surrounding with cleared labour market and insofar a fixed supply. Here a rise of investment induces a rise of savings, which means a reduction of consumption, which leaves total demand unchanged.

In the case of the neoclassical closure a rise of savings means a reduction of consumption and induces a rise of investment compensating the fall of consumption. It is used in growth theory and in by far most CGE models. It can be interpreted as the reduced form of a perfect capital market, where all savings are supplied and transformed into investment. The interest rate equilibrates the market: A rise of savings reduces the interest rate and raises investment. In an open economy the current account of international trade has to be taken into account additionally, which complicates the analysis requiring further closure rules in relation to exchange rate regimes (Taylor and Lysy 1979, Dewatripont and Michel 1987).

Sen (1963) defined the “Keynesian closure” allowing for an independent investment function, in combination with an imperfect labour market with unemployment, where labour demand is explained by a flexible real wage rate. In other words: In a Keynesian model with unemployment the neoclassical property of a fixed production in the short run does not exist. The nominal wage rate is fixed in the short run by contracts, but a change of the GDP price moves the real wage rate and this pushes employment and production. Insofar the neoclassical consistency problem for supply and demand of GDP does not exist, and investment can be independent from savings, even though it has to match savings in the solution, which is of course the result of the interplay of all variables. So the term “Keynesian closure” is misleading since a Keynesian model does not require a closure rule because supply and demand are fully flexible and are determined interdependently in the equilibrium of the circular flow of income.

These considerations show that neoclassical models have the well-known property of the dominance of the supply side of the economy, whereas fully developed Keynesian models depict a well-balanced interdependency of both market sides. Therefore, it is not true that in Keynesian models the demand side dominates. Demand side models are only the simple multiplier models, which we better should call “Incomplete Keynesian Models”.

How is investment demand explained in Neokeynesian models? Optimal capital input facing

a substitutive technology is given, if the capital output ratio – the relation between the capital stock and the expected capacity output – depends on the relative user cost of capital. Investment demand is net investment – the change in the stock of capital plus the replacement of losses in the capital stock. This specification is not complete, because the imperfections of the capital market are not taken into account. Greenwald and Stiglitz (1987) argue that suppliers of capital in special situations may not accept the amount of capital demand because of risk considerations, which may induce credit rationing. They do not try to clear the market via rising interest rates fearing that increasing interest rates might reduce the return to the supplier of capital either because the mix of applicants changes adversely or because they expect that borrowers are induced to realize riskier actions. Greenwald and Stiglitz (1987) further argue that also borrowers could behave in a way that restricts the investment decisions because they see risks that they do not want to bear. Such effects can be incorporated in our specification of the investment demand function with very pessimistic expectations for capacity output.

In any case, investment demand in Neokeynesian models is somehow modelled in an accelerator approach linking the level of investment to the change of output giving the system dynamic properties allowing for a cyclical development of the economy but also introducing stability problems which has already been shown by Hicks (1950).

2.3 GOODS MARKETS

The Neokeynesian discussion on the stickiness of goods markets prices is focusing the question whether the neoclassical property that a fall in demand induces a reduction of the market price holds also under conditions of imperfect competition. This question is important, because there is much evidence that most goods markets have imperfect structures (Hall 1986).

Akerloff and Yellen (1985) discuss the reaction of a firm supplying under monopolistic competition, which faces the reduction of demand of the total industry moving the demand function of the firm to the left. Before this movement, the firm maximized its profits choosing a price that equalizes marginal revenues and marginal costs. After the movement of demand at the actual price and the new quantity, marginal revenue is bigger than marginal cost. Therefore, profit maximization would require a reduction of the price until the marginal revenues and marginal costs again equilibrate. But it has to be mentioned that the incentive to reduce the price and to realize the additional profit depends on the steepness of the marginal cost curve and that of the marginal revenue curve. The more marginal costs fall when output declines the greater is the incentive of the firm to lower its price. The more the marginal revenue curve shifts to the left the smaller is the incentive for the firm to lower its price. In any case, the losses are very small so that already small costs of the price change itself (menu costs) can outweigh the advantage of the price change. Romer (1993) discusses four effects that influence this incentive. Blinder (1994) presents 12 different micro foundations for sticky prices and discusses the result of an empirical study testing their evidence.

Stiglitz (1984, p. 355) concludes in a paper with micro economic arguments favouring price stickiness: “I suspect that some of these theories may provide a better description of some markets, others of other markets; there is no compelling reason to believe a single theory provides the explanation of price rigidities in all markets. In these theories firms behave all

"rationally"; an alternative "explanation" of seeming price rigidities is that firm's managers act according to certain rules of thumb, for example, those that entail a mark-up over average costs. Though such "theories" – if they can be called that – fail to explain how or when mark-ups change, as they undoubtedly do, they may provide as good a description of the short run behaviour of the firm as our more sophisticated theories". The recommendation of Stiglitz is very helpful, since the macro-econometric models applied in economic-environmental research are typically multi-country/multi-industry models with thousands of prices that have to be explained. Insofar it would be a huge task to identify which of the more sophisticated approaches can be identified in which industry and country. Further, it is clear that the variables needed to estimate more sophisticated approaches are not available in such a context.

A further aspect that argues for mark ups over average costs is the information, which firms have about their marginal revenue function. It can be doubted whether this information is solid enough to base optimization on it.

If price rigidity is given with mark-up pricing then prices are not equilibrium prices and production is determined by the prices set and demand reacting to them. A determination of production via a production function is then inconsistent. Or in other words: The determination of output by a production function assumes that firms realize permanently an optimum: Optimal factor demand as input in the technology description of the production function creates optimal supply and prices are determined equalizing demand and supply. Either the price is determined by market clearing and supply is determined by the production function (neoclassical case), or the price is set by the supplier and production is given by the clearing of the market (Neokeynesian case).

From this follows that in the Neokeynesian case the specification of the factor demand system is more than deriving optimal factor inputs based on a production function. There are some degrees of freedom that can only be filled by empirical analysis. But of course the neoclassical approach is a starting point for the econometric estimation of the system of factor demand functions.

2.4 CONSEQUENCES FOR THE IMPACT OF ENVIRONMENTAL POLICY

These short theoretical considerations allow drawing some first rough consequences for the impact of environmental policies.

The impact on employment is quite opposite in the two cases: In the neoclassical paradigm there are only effects on employment, if the policy affects the labour demand function by technical progress or the labour supply function. In any case there will be full employment. In the Neokeynesian paradigm every policy has effects on employment and the unemployment ratio.

The impact on GDP is also controversial: In the neoclassical paradigm a positive impact on GDP can only be met by supply side elements like technical progress which raises factor productivities or a rise of total savings which raises investment and thus the capital input in production. In the case of higher labour productivity the labour demand curve shifts to the right and the production function shifts upwards, both effects generate higher production and value added, which raises income and consumption. A policy induced rise of demand

elements can't have an impact on GDP: Total investment is determined by total savings and a rise of total consumption would mean a reduction of savings and investment.

In the Neokeynesian paradigm technical progress has a clear positive impact on GDP only in the case of a reduction of intermediate inputs. Here value added, income and consumption would rise. A rise of labour productivity will reduce costs and prices and thus raise demand. On the other side a rise of labour productivity means a reduction of labour input and income, which reduces consumption. A similar relation is given for rising capital productivity, which reduces investment. Whether total demand and GDP will rise or fall is driven by the relation between the price elasticity and the income elasticity of demand. Further a rise of demand elements directly pushed by policy, which is not compensated by the fall of other elements, has always a positive impact on GDP.

3 THE EFFECTS OF MARKET IMPERFECTIONS IN THE MACRO ECONOMIC CONTEXT

The Capros experiment allows comparing the macroeconomic interdependencies of the neoclassical (CGE) and the macro-econometric (ME), which can be also characterized as Neokeynesian, because this attribute refers to the theoretical background and not to the – in our discussion less important – method of parameterization. This comparison is possible without running into complexity problems, because the models are reduced to a single goods market that is interacting with a labour market and the international trade market. The specifications of the equations of the CGE model are close to the World Bank Model (De Melo 1988). The equations of the ME model are identical without those who describe the determination of market prices and supply. In relation to our discussion in the previous chapter, the clearing of the foreign market in the CGE model is additional. In the CGE model, the exchange rate belongs to the prices that are determined by the equilibrium conditions. In the ME model exports and imports can be different and the exchange rate is driven by the relation between the domestic price and the foreign price and the trade balance as a second explaining variable. This gives additional aspects for divergences in the simulation results.

The parameters of the models have been estimated econometrically with data about the Greece economy over the period 1965 to 1985. Both models have been shocked in policy simulations over the period 1974 to 1985.

This experiment does, of course, not tell us how every CGE model and every ME model reacts on the policy shocks. This is so, because the specifications even inside these model classes may vary markedly. The comparison between the results of the CGE and the ME gives us only information about the fact how perfect or imperfect markets influence the properties of the models. The following three groups of shocks have been simulated:

1. development aspects
    - increase in public investment
    - increase in technical progress

2. tax policy aspects
    - income taxation
    - value added tax
3. foreign trade aspects
    - increase in foreign prices
    - increase in foreign demand
    - liberalization of foreign trade

Since the foreign trade aspects are not in the centre of our interest we do not look at these results.

In the Neokeynesian model the increase in public investment raises production, which induces private investment. Higher production means lower unit costs and prices, which raises real disposable income and thus consumption demand, so that a positive multiplier/accelerator process is induced. The reduced price level raises exports, the imports rise due to the higher production. The real wage rate rises, which diminishes a bit the expansion of labour demand induced by higher production.

In the CGE model a totally different development takes place: A rise of public investment exacts a reduction of private investment since savings are constant. In the following years production is reduced because the capital stock is lower. This creates more negative effects on income and consumption.

The primary effect of a rise in Hicks-neutral technical progress in the Neokeynesian model is a reduction of capital and labour, which directly diminishes investment and via a reduction of labour income also consumption. In total, production is reduced more strongly than the inputs of capital and labour, which means that labour and capital productivity fall, which raises unit costs and prices and lowers exports inducing a further reduction of demand. The higher domestic price also raises imports, but the fall of domestic production overcompensates this effect, so that imports eventually also fall.

In the CGE case, the technical progress primarily raises profits and thus consumption and private savings. More savings induce more investment. Via this process, the higher income generated by technical progress finds its production and after this adjustment the capital and labour inputs are the same as before the shock in spite of the factor saving technical progress. It is a complicated procedure but it is generated instantaneously by the equilibrium assumptions. In the following years further expansion is generated by the accumulation process.

A rise of the income tax for employees will in the case of the Neokeynesian model reduce consumption, which diminishes production and also investment. A negative multiplier/accelerator process is induced. The lower production raises unit costs and prices, which further diminishes demand by reduced exports. Imports follow the development of production. The reduced production does only very slightly diminish labour demand, because the tendency to falling productivity and raising prices generates falling real wages, which stabilize labour demand. Thus, the reduction of production hits the input of capital. Since it is assumed that the tax revenue raises savings of the government, a recycling to the circular

flow of income does not happen.

The CGE model once more shows a different reaction: The taxation of employees reduces consumption, but the tax revenue is given to the government and raises its savings. Since it is assumed that all savings serve as capital supply and this is always demanded by investment, now this variable rises. So total demand is not affected and production does not change in this first period. But in the following periods a growth process is triggered: The investment of the first period raises the capital stock, production, income and consumption demand and savings and investment and so forth in the next periods. An accumulation process has been induced.

The increase of the income tax for profits has for both models nearly the same effects as the increase in the income tax for employees.

The increase of the tax on value added raises first the consumption price and diminishes in the Neokeynesian model the real disposable income of households. This reduces production and investment inducing a negative multiplier/accelerator process. The reduction of production raises unit costs and the production price, which gives rise to further demand reductions from exports. Imports will be reduced due to a fall in production. This effect will be partly compensated by a higher domestic price level. Also here the tax raises savings of the government and does not affect public spending.

In the case of the CGE model we also start with a rise of the consumption price. But here the story is – as in the other tax scenarios – completely different from the solution of the ME model, because also here the tax revenue raises the savings of the government, which pushes investment. As in the other tax scenarios an accumulation process is induced: Investment raises the capital stock, this pushes production, income and demand including investment etc.

The simulations of Capros et al. (1990) do not cover the case of taxes on factor inputs, which are of course important in economic-environmental simulations. Nevertheless, with the background we have so far we are able to assess the effects. A tax on factor inputs will raise marginal costs as well as unit costs. Normally some substitution will take place because the purchasers' price of the input rises, but since in most cases the elasticity of substitution will be below one in absolute terms, marginal and unit costs will rise. This means that the price of the industry that uses this input will increase and demand and production will fall in both model types. In the case of the Neokeynesian model the reduction of production may induce additional price increases. In both models the lower production will induce further negative income and demand effects. The higher prices will in both models reduce exports and push imports, which has further dampening effects.

If the tax revenue is saved by the government the Neokeynesian model predicts a small reduction in the interest rate without measurable effects on investment. In the case of the CGE model the total tax revenue is transformed into investment, which induces strong expansion effects.

If both models have independent investment functions, the results of this standard simulation in economic-environmental analysis will be fairly similar. But if the CGE model uses the neoclassical modelling of the capital market (neoclassical closure rule) we also will have very big differences in results.

4 THE PROBLEM OF EXOGENOUS GROWTH WITHIN REFERENCE SCENARIOS

In assessing the implications of specific policy measures a reference solution of the model is compared with an alternative solution, in which one or more variables have been shocked against their values in the reference. The deviations between both simulations give all direct and indirect effects of the shock.

Such simulations can be done for the past or for future periods. In the first case the reference would be a historical simulation with historic values only for the exogenous variables and the policy parameters. A so-called “counterfactual simulation” gives then the alternative with different parameters of the policy variables. An actual example is given by Meyer and Meyer (2013). Especially in economic environmental simulations the challenges for policy formulation are given for the future, since these are in most cases long run forecasts. Here the reference is a forecast with the model with policy parameters that exclude the policy in question in terms of business-as-usual. Econometric models are tested for the ability to produce a plausible forecast.

Most CGE models have not econometric underpinnings. Their parameters have been taken from the literature (elasticities) and the rest of them have been calibrated on the basis of one data point. It is rather unlikely that such a system produces a plausible long run forecast. Therefore, pathways either for GDP or for factor productivities are taken from exogenous sources and the model is calibrated to that pathway. If GDP is exogenous, factor productivity can be calculated endogenously by the CGE model, in the other case GDP is estimated endogenously by the CGE model. An extensive discussion of the pros and cons of the different approaches is found in Fontagne et al. (2013).

We want to address a more fundamental point. This procedure seems to be acceptable, if the analysis is done to evaluate single policy instruments. The typical questions in economic environmental applications are: What is the effect on extractions and emissions and what is the effect of the instrument on socio-economic variables. Typically, these effects are measured as percentage deviations from the reference. Therefore, the levels of the variables of the reference are of minor interest. The argument is: If the reference is wrong, this failure is also contained in the alternative scenario. Since policy evaluation is interested only in the differences between both scenarios the failure will in most cases be eliminated.

But if the user of the model is interested to compare a situation without a certain policy with an alternative situation in which this policy is implemented in terms of levels of the central variables, we have a different situation. If for example the question is which consequences a business-as-usual policy has for the economy and the environment compared with a situation in which an engaged policy mix will be implemented during the next 35 years, the levels of the variables are of interest and not only the deviations from the reference. In this case, the exogenous construction of a reference is very problematic, because the policy implications of the business-as-usual do not enter the forecast. Dixon and Rimmer (2012) – very successful CGE modellers - argue that these applications become more important and they recommend improving the forecasting qualities of CGE models.

When comparing model results of CGE and of Neokeynesian models one has to note that

the levels of all economic variables, emissions of pollutants and extractions of resources may already be different in the business-as-usual simulation. It is consequently very difficult to understand to which extent the endogenous model relations and the calibration to an exogenous path is responsible for the differences. Further, it is clear that such differences in the business-as-usual simulation are mirrored in the alternative simulations: If a lower emission path is projected in the business-as-usual simulation, it will be easier to meet a concrete emission target for the future than in the opposite case.

5 COMPARISON OF THE SIMULATION RESULTS OF EXIOMOD (CGE) AND GINFORS (ME)

The central research question of the POLFREE project (POLFREE.eu) is: How to reach the environmental targets of the vision for Europe till 2050?

- CO_2 emissions reduction by 80% compared with 1990,
- Reduction of the cropland footprint by 30% compared with 2005,
- Raw material consumption 5 tons per capita,
- Water exploitation index below 20% in all EU countries.

The modelling of target scenarios of EU environmental policy has been elaborated until now only for several aspects as climate policy or for abiotic materials but the analysis of scenarios for all targets simultaneously mentioning the complex interrelations between them is new. How can the targets simultaneously be met and which socio-economic impacts will be induced? The answers are given by an integrated assessment modelling exercise, in which the economic environmental models GINFORS (Meyer et al. 2015) and EXIOMOD (Hu et al. 2015) have been linked with the vegetation model LPJmL (Beringer et al. 2011). The modelling work is embedded in a scenario framework (Jäger and Schanes 2014) which defines in addition to the EU targets the cooperation in the other countries of the world and allocates plausible policy mixes (Wilts et al. 2014) to different assumptions on governance (O'Keeffe et al. 2014).

The reference of the GINFORS simulations is a business-as-usual projection assuming for the EU that the already implemented climate policy is maintained and that no activities to reduce material extractions are taken, and that in the Non-EU countries no environmental policy action at all will be implemented.

The reference for the EXIOMOD model is calibrated on the CEPII EconMap v2.2 data. Therefore, the macroeconomic development of the reference is exogenous for the model. Insofar it is not a business-as-usual forecast of the model itself and the results cannot be interpreted as such.

This example shows that these references cannot be compared, because one of them is a projection under specific policy assumptions, whereas the other reflects a reasonable future that is consistent with supply side modelling based on assumptions about labour and capital productivities and factor inputs and is independent from the model, which is calibrated to this development.

For the three alternative scenarios a set of about 30 different policy instruments (information, economic and regulation instruments) have been allocated to three alternative scenarios with different governance and international cooperation assumptions. In a large set of simulations it was tried to define policy mixes which meet with EXIOMOD and GINFORS (both linked with LPJmL) the already mentioned targets. For information- and regulation instruments, the implementations have been taken from the literature and the parameters of the economic instruments (tax rates etc.) have been iteratively changed.

In the case of GINFORS it was possible to meet more or less the targets with the policy mixes, for EXIOMOD the procedure did not converge. Very strong rebound effects occurred and the authors speak about conflicts between the targets (Hu et al. 2015, pp 24).

This discrepancy in the properties of the models is caused by the different parameterizations of the models. All price and income elasticities in demand- and supply functions of GINFORS are estimated econometrically. The model has an empirically evaluated structure. In the case of EXIOMOD the elasticities of substitution are assumed. Especially the assumptions about the price elasticities for intermediate demand, for consumption and for imports seem to be responsible for the result.

The price elasticities for intermediate demand are zero for EXIOMOD, which means that taxation of resource intensive intermediate goods is not able to change the structure of production directly.

On the other side information instruments induce improvements in resource productivity, which over all stages of production shifts supply functions to the right. In the case of consumption goods the price elasticity of demand is with -1 rather high in absolute terms. Here the shift of the supply function to the right generates a new equilibrium with a lower price and a higher demand and production, which raises finally the input of resources. This rebound effect is strengthened by a strong reaction of imports, which have a price elasticity of -5. So the reduction of the consumer price will strongly reduce imports and push production further.

In GINFORS intermediate demand is price dependent with econometrically estimated specific elasticities for the different product groups. Further the econometrically estimated price elasticities of consumption and of imports are significantly lower than those of EXIOMOD, which reduces rebound effects.

To get near to the targets it was necessary for EXIOMOD to assume exogenously given ad hoc improvements in the energy and material efficiency. Consequently, the presented results are only partly induced by the policy mixes. The strong rebound effects of EXIOMOD are an artefact.

The economic results are also quite different (Distelkamp et al. 2015): The structural change towards a resource efficient economy induces strong investment, which in the case of GINFORS – at least partly – is additional investment compared with the reference, which drives GDP and employment. Sectoral investment is determined by the needed capital input of sectoral production, which is derived from econometrically estimated sectoral investment functions. Of course, investment in the old technologies is reduced, but the total effect is positive. EXIOMOD has a so-called neoclassical closure, which means that macroeconomic investment is determined by savings. Therefore, a rise in investment in new technologies is

by assumption accompanied by a fall of other investments, which totally compensates the first effect. Since the labour market is cleared, there are also no effects on employment.

6 CONCLUSIONS

Summarizing we see that Neokeynesian modelling creates totally other properties of macro models than the neoclassical model. All markets are imperfect and firms are price setters and not price takers. Permanent unemployment is possible in the Neokeynesian case, whereas in the neoclassical model full employment is given.

In Neokeynesian modelling prices of industries react to unit costs or incorporate adjustment costs inducing stickiness of goods prices instead of being determined by the market equilibrium. In the neoclassical case a fall in demand reduces the equilibrium prices, whereas in Neokeynesian models a fall in demand lowers production.

The different modelling of the capital market implies in the case of neoclassical model a macroeconomic closure that creates the dominance of the supply side in macroeconomic terms whereas Neokeynesian modelling allows for a balanced influence of macroeconomic supply and demand.

The labour market plays a central role: If a perfect market is modelled we get the problem of inconsistency between supply and demand, if not a closure rule is given, which guarantees that total macroeconomic demand equals supply. In most CGE models this rule determines investment by savings with variations coming from international trade. As we deduced from our theoretical considerations and as have seen in the Capros experiments as well as in the comparison of simulations with the models EXIOMOD and GINFORS this closure rule is responsible for the strongest differences in results. Especially in environmental modelling technological change plays a central role. Investment is the economic activity that is driving the story. In neoclassical modelling investment in new technologies may happen, but with a neoclassical closure rule it will always reduce investment in other activities. This excludes by assumption that an investment in new technologies can push GDP and employment. In Neokeynesian modelling investment in new technologies will rise and boost the investment of the industries concerned and endogenously the investment of the industries with “old” technologies will be reduced. The total effect on investment is open; it can be positive or negative depending on the capital/output ratios of the technologies and other parameters.

Technical progress is the central driver of positive GDP effects in the neoclassical paradigm, in the Neokeynesian paradigm the effect on GDP can be positive or negative. The result depends on the relation of the price elasticity of demand and its income elasticity.

The neoclassical model describes the development and reactions of a perfect economic world, whereas the Neokeynesian approach tries to identify the deviations from the perfect world testing the assumptions of the theory using the method of econometric estimation for the parameterization. This difference is very important since there is strong evidence that the inputs of resources and especially that of materials are not used efficiently.

It is no question that both modelling approaches have their justification and problems: The neoclassical approach can serve as a reference showing how the economy would develop, if a general equilibrium would exist, but to use it for concrete policy evaluation should be called into question. The Neokeynesian approach claims that it accomplishes this, but this ability depends on the empirical validity of the underlying models.

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