Modelling environmental, economic and employment effects

of resource savings in Austria

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Abstract:

The paper addresses possible environmental, economic, and employment effects on the Austrian society when companies increase their investments in resource productivity. Together with the project sponsor and experts four scenarios were defined, which specify how an increased dematerialisation may look like. The scenarios were simulated for the period 2005 - 2020, using a new integrated ecological-economic model for Austria. This model integrates an input-output model with an energy and a resource use model and is linked to a world model to show the effects of international trade on the Austrian economy.

The modelling results show that savings on resource costs may lead to substantial economic improvements and employment increases. However, due to rebound effects, the efficiency gains do not provide savings in the use of resources. Thus, increasing resource efficiency is not enough to achieve a sustainable development and must be accompanied by other activities and measures.

1. Introduction

A promising strategy for maintaining high and stable levels of economic growth without social and environmental externalities is improving resource productivity. Improving resource productivity means getting more economic value from each unit of production, thus “decoupling” economic growth from resource use. This is an important goal for the transition to a sustainable development.

Thus, the Austrian Federal Government defined the increase of resource efficiency around the factor 4 and the absolute decoupling of resource use and economic growth as central goals of the Austrian Sustainability Strategy (see Austrian Federal Government, 2002, p.36). However, Austria is far from reaching these ambitious goals with the current activities and measures. Although the increase in resource consumption has decelerated in the last decades, the necessary absolute reduction of resource use is still not achieved (Haberl et al., 2006).

If the present growth trends continue, substantial improvements of resource efficiency must be achieved to reach economic growth, an increase in employment and a decrease of resource consumption at the same time. These improvements can be realized to an important part by efficiency gains in companies.

A recently finished Austrian project, named RESA (Stocker et al. 2007), addressed possible environmental, economic, and employment effects on the Austrian society under the assumption that companies reduce their resource use as a consequence of increased resource productivity due to technical improvements. Together with the project sponsor and experts, four scenarios were defined which specify how an increased dematerialisation may look like. These scenarios were simulated until 2020 using a new integrated ecological-economic model for Austria.

The paper introduces the model (chapter 2) and describes the results of four scenarios (chapter 3), aiming at a reduction of resource use and an improvement of the economic performance at the same time. Based on the scenario results we derive some conclusions with respect to policy making in chapter 4.

2. The Integrated Environment – Energy – Economy Model „e3.at"

In this chapter we briefly introduce the new integrated environment – energy – economy model e3.at (for a detailed description see Großmann et al. 2007), that was used within the project RESA two analyse different scenarios aiming at resource use reductions. The model integrates an input-output model with an energy and a material model in order to show the manifold relationships between the economy and the environment. Furthermore, it has a soft link to a world model to illustrate the effects of international trade on the Austrian economy. It is an econometric model for Austria which is built following the German model PANTA RHEI[1]. However, the Austrian model is not a copy of the German model, but uses general construction principles that are also valid

1 PANTA RHEI has been used for many simulations of suggested policies (see for example Meyer, 2001; Meyer and Welfens, 2001; Lutz et al., 2005) as well as for the evaluation of implemented policies such as the ecological tax reform in Germany (Bach et al., 2002). Furthermore, PANTA RHEI was a central part of several studies seeking sustainability strategies for Germany (Spangenberg, 2003; Coenen and Grunwald, 2003; Keimel et al., 2004; Bockermann et al., 2005).

for other countries, and is then adapted to Austrian specifications. The general features of the model are presented in the next sub-section followed by a short description of the model structure and components.

2.1 General properties

e3.at is a multi-sector model that permits the illustration of structural change and as such is able to recognize particular burdens on certain industries. This fact is important for the design of a social reconciliation and supporting measures to offset these burdens. The transition to a sustainable development can be arranged thereby with consideration on social and economic compatibility.

The model also illustrates the interdependencies of the environment and the economy. So it is possible to analyse not only the effects on economic growth and employment but also on resource use and CO_2 emissions. The integration of the environmental and socio-economic systems with their various linkages and feedbacks is needed to appropriately assist policy-makers in their decisions for suitable strategies to tackle the most challenging environmental and socio-economic problems.

The philosophy of the model e3.at is that agents are acting on imperfect markets under conditions of bounded rationality. The application of econometric methods facilitates an empirically validated parameterization of the model. As empirically validated model it is able to produce reliable baseline forecasts, which, confronted with environmental and economic targets, allow the calculation of sustainability gaps.

The model e3.at is based on two principles of construction: bottom–up modelling and full integration, which are typical characteristics of the INFORUM philosophy (Almon, 1991). Bottom–up means that all 57 sectors are modeled in great detail. Macroeconomic variables such as GDP or disposable income or the consumer price index are calculated by explicit aggregation. Full integration implies complex modelling, which simultaneously depicts inter-industry connections and the generation, distribution, redistribution and use of income for the demand of goods. It further means that the influence of the economy on the environment and at least the short-term effects of the change in use of the environment on economic performance are depicted.

The disaggregated structure of the model is necessary, because the linkage between the economy and the environment requires a detailed production structure. With regard to data, time series of input–output-tables are consistently linked with time series of a full SNA system.

2.2. Overview of the structure of the model

[Insert Figure 1]

Figure 1 provides a first impression of the structure of the model, which comprises the following components:

- Economic model, which consists of an input-output model, the system of national accounts (SNA), and the labour market.
- Energy model, which illustrates the relationship between economic development, energy use and CO2 emissions. It comprises the energy demand, the transformation and the energy supply.
- Resource model, which allocates the domestic and imported material inputs to those

sectors responsible for the material extraction.

- Foreign trade model, which links the Austrian trade to the global model GINFORS[2] (Meyer et al., 2005). GINFORS delivers export demand and import prices for the economic part of the model system.

In the following we describe the economic model and the resource model, which are in the direct focus of this paper, in detail.

2.2.1. The economic module

The economic module has a very high degree of endogenisation. Tax rates and the labor supply are exogenous. As already said, sectoral exports and import prices are taken from GINFORS, but they are endogenous to that system. The high degree of endogenisation has the advantage that the effects calculated in simulations are complete.

In addition to the usual interdependencies of the circular flow of income, e3.at depicts the interdependencies of prices and volumes as well as of prices and wages. The model is nonlinear, because there are many multiplicative connections of variables in definitions, and many behavioral equations are estimated in double logarithms. It is a dynamic model because of the capital stock adjustment and the lags in behavioral equations. The nonlinearity combined with the interdependency of the system requires an iterative solution procedure, which is given with the Gauss–Seidel algorithm.

The dynamic structure allows a year-by-year solution for a longer time path. The model is running in a historic time, and time cannot return.

2 GINFORS calculates the socio-economic and environmental development of 53 countries, which are linked by a bilateral multi-sector (25 commodities and one service good) trade model.

If we combine these properties with the already mentioned assumption of bounded rationality of the agents, which underlies the specification of the behavioral equations, the system can be qualified as an evolutionary model.

On the other hand, it could be called an econometric input–output model (West, 1995), since the econometric estimation of parameters takes place and the input–output connections are there.

For a better understanding of the theoretical position of the model, the following point should be noted: in general, the input–output approach is classified as demand oriented.

However, this is not the case for the model e3.at. It is true that demand determines production, but all demand variables depend on relative prices, and prices are given by unit costs of the firms using the mark-up hypothesis, which is typical of oligopolistic markets. In this regard, the difference between neoclassical models and the model e3.at lies in the assumed market structure and not in the accentuation of one side of the market or the other. Firms set their prices depending on their costs and the prices of competing imports. Demand reacts to price signals and thus determines production. So the e3.at model has both demand and supply elements.

The economic part of the model further comprises a complete SNA system to calculate the aggregate variables and the income redistribution between the government, households, firms and the rest of the world. So for these institutions disposable income and their flow of funds can be estimated, and the budget of the government including fiscal policy and the social security system are endogenously depicted.

2.2.2. The material module

The material input module calculates the direct material inputs (DMI) according to the „Eurostat guide on economy-wide material flow accounts“ (EUROSTAT 2001). The DMI comprises “the flow of natural resource commodities that enter the industrial economy for further processing. Included in this category are grains used by a food processor, petroleum sent to a refinery, metals used by a manufacturer, and logs taken to a mill” (Adriaanse et al. 1997, p. 8).

As can be seen from Figure 2 the material module differentiates 12 material categories that are part of three material groups (biomass,minerals, and fossil fuels). The model covers the extraction in Austria as well as the imported materials, which are induced in other countries by the Austrian imports. The material data was provided by a EUROSTAT time series from 1970 to 2001 (EUROSTAT, IFF, 2004).

[insert figure 2]

Domestic material extractions (in tons) are linked to the extracting production sector. The direct physical material imports are driven by the imports in monetary terms measured in constant prices. It is assumed that the development of material extraction and of economic variables is proportional.

The modelling of the effects of material savings considers the following process levels: At the extraction level (1) no savings are possible. This means that the production value and extraction of material develop proportional. The extractor delivers either to final consumption (2) or to the first process level (3). In both cases material savings are possible due to increased efficiency. Goods produced by the first process level are used by the final consumption (4) as well as by other process levels (5). Finally one can say that there are various interdependencies affecting the material extraction.

If the comparison of the development of the production value and material consumption showed that the production value was higher then material consumption an increased material productivity was assumed and the input coefficients (in constant prices) in the baseline scenario were adapted. In addition, it is possible to change the input coefficients in the scenarios.

Indirect effects induced by structural change of the input–output coefficients, and the change of the structure of final demand, which are both endogenous, are very important for the structure of physical inputs.

3. The Scenarios

Together with the project sponsor and experts[3], four scenarios were defined which specify how an increased dematerialisation may look like. The scenarios aim at a reduction of resource use and an improved economic performance at the same time. Two scenarios ("Aachen I" and "Aachen II") focus on efficiency gains due to technological changes, while the others deal with consumption changes and working time reductions.

Starting from the base line scenario, we describe the features of all scenarios and subsequently present their results.

3 Within the project a workshop was organised were the project team discussed with the project sponsor and some invited experts possible scenarios.

3.1 The baseline scenario

The baseline forecast for the period 2005–2020 assumes “business as usual” (BAU) with regard to economic policy (labor market, income taxation, social security system etc.), energy and environmental policy. Thus far the baseline scenario reflects the policy situation of 2004. By comparing the BAU scenario with the policy scenarios introduced below it is possible to recognize effects of changes induced by policy measures.

The baseline scenario shows a rise of gross domestic product (GDP) to 313 billions € in 2020. This means a long-term growth rate of 2 % (see figure 3).

[insert Figure 3]

As can be seen from Figure 4, employment shows an average increase of 0,5 % per year.

[insert Figure 4]

The development of employment in different industries shows that service sectors benefit from economic growth, while the share of persons working in manufacturing sectors decreases (see Table 1).

[insert table 1]

The material inputs (domestic extraction plus imported materials) increase from 167 Mio. tons in 1990 to 225 Mio. tons in 2020 (plus 35 %) (see Figure 5).

[insert Figure 5]

Compared to the development of GDP the material inputs increase less than GDP: the average growth rate of material inputs is 1,2 % while that of GDP is about 2 %. In other words, the material productivity – measured as GDP in Euro in constant prices per kg of

DMI - is rising (see Figure 6).

[insert Figure 6]

Differentiated by material categories, the highest increase of material consumption can be expected for biomass from forestry. The DMI raises from 27,6 Mio. tons (2005) by about 44% to 39,8 Mio. tons (2020). The use of ores will almost double from 18 Mio. tons in the 2005 to 31 Mio. tons in 2020. This increase is only driven by the augmenting imports because in Austria hardly any ores are extracted. There is also a substantial increase in construction materials of about 17%. from 2005 to 2020 stemming from the growing construction sector.

3.2 The scenario „Aachen I“

3.2.1 Scenario outline

The scenario „Aachen I“[4] is based on the idea that there is a material savings potential in manufacturing sectors given by inefficiencies as unnecessarily heavy construction and vehicles, unnecessary material waste in industry, construction, trade and private households, and lack of recycling.

Inefficiencies in production can be identified and removed by information and

4 The scenario „Aachen I“ is based on the „Aachen Scenario“ (Fischer et al. 2004) which was developed and analysed within a German research project (see Distelkamp et al. 2005). With respect to the Kathy Beys Foundation, Aachen, who sponsered the German project, the scenario was named “Aachen” scenario.´We have decided to adopt this name for our scenarios, because we calculate the same material cost savings that were analysed for Germany also for Austria.

consulting[5]. The experience of consulting firms is that material costs of manufacturing firms, in construction and in public administration can be reduced by 20%, which is an average that may vary in the different sectors. Of course, the reductions of material inputs cannot be achieved without additional costs for consulting and investment in machinery. The experience of the consultants shows that savings of material inputs result in additional consulting and capital costs of the same magnitude for one year. One third of the additional costs are consulting costs, two thirds are capital costs. The economic advantage is given, because the additional consulting and capital costs are non-recurring, whereas the savings of material and energy inputs are given forever.

In the scenario "Aachen I" we use these assumptions, but we view the consulting experience conservatively: We assume that resource costs of manufacturing sectors, construction and public administration can be reduced by 20% of the material costs, but it takes 15 years to realize this potential in all manufacturing firms. The reductions of material and energy inputs start in the year 2005 and will increase linearly to 20% in the year 2020. In reality there will also be product innovations, which will raise final demand. We ignore, however, this effect in the simulations for this project.

5 Information means that the government can support campaigns, which stress the importance of material management for the performance of the firms. Agencies could be founded, which organize the dissemination of knowledge about saving potentials in material consumption. Consulting means the concrete activities of engineers searching and installing the known best practice technologies especially in smaller firms. The government could be the moderator of a process in which private firms organize the knowledge transfer necessary to dematerialize production processes.

3.2.2 Scenario results

Dematerialisation has two direct effects on the macroeconomic activity. First, there is a cost reduction in manufacturing, construction and public administration, and secondly, the sales of the deliverers of material - which belong to the manufacturing sectors - will be reduced. So there are winners and losers: winners are domestic firms, whereas domestic manufacturers of intermediate products and imports are losing. Thus, the direct effects must include a rise of GDP.

There are also a number of indirect effects. Cost reductions induce lower prices. If prices reduce less than costs - which is normally the case - profits increase. This raises tax revenues and income of households. Both effects vitalise final demand and sales, production and employment.

In total, dematerialisation will induce a strong stimulation of the economy. The GDP in constant prices increases in 2020 by 24 % from 312,6 billions Euro in the baseline scenario to 389,1 billions Euro in the scenario “AachenI” (see Figure 7).

[insert Figure 7]

The reduction of material inputs has a strong positive impact on material productivity. Figure 7 shows that in the Aachen I scenario 18 % less material would be used in 2020 than in the baseline scenario. However, if we consider the development between 2005 and 2020 we can see that in absolute terms the material extraction would not be reduced because of the rebound effect. Figure 8 shows the levels of total material input for the baseline and the Aachen scenario.

[insert Figure 8]

Employment depends on both production and the real wage rate: production has a positive, the real wage rate a negative effect on employment. In the scenario “Aachen I” employment rises, because the negative effect on employment from the real wage rate will be overcompensated by the positive production effect. Rising employment means a further positive effect on household income and from there to final demand. Employment will rise continuously, so that in the year 2020 the employment level is 2,4 % or about 81.000 persons higher than in the baseline scenario.

As Table 2 shows, the structure of employment changes: employment in manufacturing is falling against the baseline, which is overcompensated by a rise in service sectors.

[insert Table 2]

An overview of the scenario results of “Aachen I” is presented in Table 3.

[insert Table 3]

3.3. The scenario „Aachen II“

3.3.1 Scenario outline

In the scenario “Aachen I” we assumed that the efforts to reduce resource inputs are the same in all manufacturing sectors, in construction and in public administration. Yet it might be more efficient to concentrate the activities on those sectors and technologies that have the strongest direct and indirect impacts on material consumption.

Thus, scenario “Aachen II” is looking more closely at potential reductions in certain sectors. In order to evaluate the actual potential for resource reduction in Austrian industries, a workshop was organised, in which the project team together with the Federal Ministry of Agriculture, Forestry, Environment and Water Management and a group of experts discussed starting points and conclusions for potential reductions.

Based on the workshop results, literature research and several interviews, the sector of construction, of wood working and processing, as well as the sector of production and processing of synthetics were selected for a closer investigation in terms of potential material cost reductions. The analysis of the single branches (for details cf. Stocker et al., 2007) resulted in the following material cost reductions: for "construction" a 10% reduction potential of the intermediate demand for "other mining and quarrying" can be assumed; for the intermediate demand for chemical products and "wood and product of woods" within the economic sector "production of rubber and plastic material" and "forestry" respectively a 10% reduction can be assumed as well.

The selection of sectors was on the one hand focusing on branches with a small and medium-size enterprise structure and, on the other hand, the extent of domestic extraction, since in the latter efficiency steps will directly lead to an improvement of the domestic situation. While large-scale enterprises have already asserted for a majority of potential cost reductions, small and medium-size enterprises still seem to hold a remarkable capacity for an increase of efficiency: experiences with (German) projects (cf. Arthur D. Little et al., 2005) show a considerable potential for the increase of efficiency and effectiveness in small and medium-size enterprises within the production factor of "material".

This scenario may be regarded in contrast to the high resource cost reductions in "Aachen I" for it deals with the effects of minimal potentials of reductions and thus draws a more pessimistic image of the future. In this sense, the whole range of potential reductions reaches from a careful evaluation for single sectors in "Aachen II" to an optimistic evaluation across all sectors. In neither scenario statements about the use of reductions resulting from reduced intermediate demands are made.

3.3.2 Scenario results

Through the reduced use of resources from the sector "other mining and quarrying" in the construction sector (-10%) the direct material input of construction materials reduces by 5 % in 2020 compared to the baseline scenario. The construction sector receives about 50 % of all deliveries of material, so that the reduction of resource use in the construction sector is 5 %.

The 10 % reduction of intermediate demand on goods from the sector „forestry" cause a reduction of material use in the sector "wood and products of wood" by 4,5% compared to the baseline scenario. The sector "forestry" delivers one third of its goods to the wood-working industry. In addition, the decreased imports of wood lead to a reduction of DMI.

The reduction of material use of the plastics industry (as part of the chemical industry) has little effect on the material consumption. Less then 10% of the produced goods are delivered to the sector „production of rubber and plastic materials". Thus, the use of cruid oil is almost not affected.

All together, the total material use (domestic extraction plus imports) decreases by 2,9 % to 219,4 Mio. tons in 2020 compared to the baseline scenario.

On the economic level there are also only small changes. The gross domestic product augments by 0,3 % in 2020 compared to the baseline scenario.

The effects on employment are similar to those in the scenario „Aachen I" but the not so strong. The total employment level is nearly the same than in the baseline scenario. Only some structural changes can be observed: In 2020 less persons will be employed in the sector „agriculture and forestry", „mining" and „other mining and quarrying". Additional jobs will be created in the sectors „construction", „hotel and restaurant services", and „public and private services".

In Table 4 a summary of the scenario results is presented.

[insert Table 4]

3.4. The Consumption Scenario

3.4.1 Scenario outline

The results of calculations from the efficiency scenarios (Aachen I and II) demonstrate that efforts to increase resource efficiency are necessary but possibly not sufficient for substantial reductions of resource use since in growing economies alleged credits are finally wasted again by rebound effects.

To avoid these effects, the project looked at scenarios of an actual decrease in consumption. It does not analyse potential motivations for the reduction of private consumption, yet discusses its effects in a kind of "what if" scenario. Considering both ecological and economic factors the reality of negative effects of a reduced level of consumption on economy and the possibilities of avoiding these potential effects will have to be examined. Our consumption scenario therefore looks at the consequences of an overall change in final demand of private households. In this context it was assumed that private consumption will be reduced by 5% in the year 2020 compared to the base line scenario while savings increase, which, however, still results in an absolute growth of consumption over time. This value has to be regarded as initial reduction and will accordingly increase by the multiplier effect. It has to be noted that the interplays and backlashes of the financial market are being neglected.

3.4.2 Scenario results

In this scenario we assume that the private consumption for all goods and services increases 5 % less than in the baseline scenario. Due to the multiplicator effect the private consumption in 2020 augments by 10,5 % less compared to the baseline scenario. Nevertheless the demand increases by 25 billions Euro (almost 20%) between 2005 and 2020, while in the baseline scenario the increase is 43 billions Euro or 33 % (see Figure 9).

[insert Figure 9]

The gross domestic product (GDP) decreases only by 5,4 %, because the exports are not affected by the domestic change of private consumption. The final demand categories investments (-4%) and public consumption (-3,3 %) are only influenced by secondary effects. The demand of imports reduces due to the lower domestic demand (-2,7%).

[insert Figure 10]

Figure 10 shows that the reduction of material use is smaller (-2,5%) than the decrease of GDP (-5,4%). The relatively minor reduction of imports (-2,2%) and of important materials like stone and wood (-2,4 and -2,8% respectively) are responsible for this result.

Employment reduces by 1,6% in 2020 compared to the baseline scenario. The reduction in the sectors „construction“ and „hotels and restaurants“ is above average, while in the sectors energy and water supply and in the manufacturing sectors positive effects can be observed.

Table 5 summarises the results for the consumption scenario.

[insert Table 5]

A damped growth of demand can be supported by a reduction of working time (see chapter 3.5) and a re-distribution of labour, whereby both the work for money and unpaid work must be considered. This means to distribute less employment on more capita as well as to provide more time to (more than) full time employees for relations, self implementation, education and care, as well as social commitment.

Less employment causes less market production and consumption thus reduced resource consumption. For the society as a whole this means less environmental consumption, more "well-being" as well as to create more jobs in a more competitive economy.

The resulting income decrease can be compensated by increasing labour and resource productivity and by the positive effects of mixed work[6] that cause less costs of the social

6 The concept of mixed work tries to connect the dynamic of development of employment with the requirements and potentials of social sustainability. It presupposes the revaluation of the so called informal work, the possibility of various multiple combinations and the promotion of transitions. It focuses more on equality of rights and participation due to the reallocation of work against the gender

system and thus less tax burden (Stocker et al., 2006).

3.5. Scenario „working time reduction“

3.5.1 Scenario outline

Scenario 4 “working time reduction” is based on the assumption of a 1% reduction of working time across all economic sectors until the year 2020 (linear slope until the year 2020 of 1%) compared to the baseline scenario. The focus of this scenario lies in the development of the labour market and examines whether the surplus of employment positions resulting from working time reductions can be compensated by the employment demand within the single economic sectors.

3.5.2 Results

A 1% decrease of working time across all economic sectors until the year 2020 causes at first a reduction of wage per employee compared to the baseline scenario. Thus, the disposable income is lower and consumption decreases. Therefore, the GDP and the material use slightly fall. The number of employees increases by about 1% or 37.400 persons. At the end, the wages are 1,2 % above those of the baseline scenario, because the creation of additional jobs resulting from the decreased working time over compensates the decrease of wages at the beginning (see Table 6).

[insert table 6]

Due to the increased labour demand (1%) there results a lack of labour force, which has

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and age groups, and on more quality of live because of the inclusion of employment in the whole live (Brandl and Hildebrandt, 2001).

positive effects for the development of wages. The working time reduction leads to a scarcity of labour supply, and thus to an increase of wages. The higher wages in turn augment the prices by 1,2 % in 2020.

A constant distribution of the structure of qualification for all industries is assumed. Under this assumption, the results show that additional jobs are mainly created for high qualified people, so that the unemployment is lower compared to other education and qualification levels (see Table 7).

[insert table 7]

The calculated effects on economy, employment and environment of this scenario are summarised in Table 8.

[insert table 8]

At the time being, the current version of the simulation model contains only basic functions for the illustration of the labour market. For a detailed analysis a segmentation of the labour demand as well as a improved modelling of labour supply are essential (see Meyer and Wolter, 2005). Moreover, a classification of age and sex is necessary.

In further analyses we have to deal with the question whether it is possible to cover labour demand at the end of the simulation period, due to demographic changes. In this respect lifelong learning and additional demand on education and training may occur. It is also important to examine whether a working time reduction is possible at all qualification levels.

4. Conclusions

The "Aachen scenarios" assume that there is a resource savings potential in manufacturing sectors that can be exploited by information and consulting. Government could be the moderator of a process in which private firms organize the knowledge transfer necessary to dematerialize production processes.

The simulations with the model e3.at show that the performance of the Austrian economy would strongly improve and economic growth and resource consumption could be decoupled, but the overall material consumption does not shrink. So there is a strong rebound effect to be expected, which allows only a relative reduction of material inputs in relation to the baseline scenario, but not in relation to historic data.

The results support the overwhelming consensus amongst academics that resource productivity will not, on its own, achieve economic growth, high and stable employment levels and a substantial reduction of resource consumption at the same time. Thus, increasing the resource efficiency is not enough to achieve a sustainable development and must be accompanied by other activities and measures. One promising strategy is to change the level and the structure of consumption pattern. Therefore we designed two additional scenarios, which deal with consumption changes and work time reductions, but only on a very general level. For a detailed analysis of changed consumption patterns and reduced working time more sophisticated scenarios have to be developed to adequately investigate their effects on all dimensions of sustainability. A change of consumption patterns, for instance, should emphasize on such goods that are particularly resource intensive. Also a more elaborated investigation of working time reductions is necessary. For this purpose however, the model needs to be improved to provide assured facts about the effects of labour time reductions. In any case, the economic advantages of increased resource efficiency seem to allow reductions in working time without losing economic competitiveness.

Concluding, it is crucial to provide an effective resource policy which is able to realise the existing potentials for efficiency increases in companies and to combat the rebound effect at the same time. The national action plan for the increase of the resources efficiency („Nationaler Aktionsplans zur Steigerung der Ressourceneffizienz“), which is worked out at present and should be adopted at the end of 2007, should consider both aspects in order to be able to absolutely reduce the energy, material and land use requirements by short, medium and long-term measures.

A reasonable package of measures must equally include firms, households and the political basic conditions (e.g. taxes or certificates). How such a mix may look like, has to be examined in further research projects in more detail.

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Tables:

Table 1. Development of employment in selected sectors (in 1000 persons) in the baseline scenario

Employees in 1000 persons	Baseline scenario			
	2005	2010	2015	2020
agriculture, hunting, forestry	25,9	25,6	25,1	24,8
mining and quarrying	85,5	85,0	85,5	86,4
manufacturing	506,7	505,7	502,1	498,8
electricity, gas, water supply	26,8	25,5	24,4	23,4
construction	234,1	233,7	229,9	227,1
wholesale, retail trade; repair of motor vehicles, personal goods	493,9	501,8	508,8	516,4
hotels, restaurants	158,5	164,1	169,8	175,8
transport, storage and communication	209,4	204,2	200,6	197,9
financial intermediation	110,6	113,9	117,3	121,0
real estate, renting and business activities	297,4	337,3	376,6	424,2
public and private services	920,6	950,9	978,9	1007,0

Table 2. Development of employment in selected sectors (in 1000 persons) in the scenario “Aachen I”

Employees in 1000 persons	"AachenI"			
	2005	2010	2015	2020
agriculture, hunting, forestry	25,8	25,4	25,1	24,9
mining and quarrying	85,3	84,8	85,8	87,3
manufacturing	505,9	495,9	482,1	468,7
electricity, gas, water supply	26,8	25,2	23,6	22,1
construction	233,7	233,8	233,1	232,8
wholesale, retail trade; repair of motor vehicles, personal goods	493,9	502,3	510,0	517,9
hotels, restaurants	159,0	169,4	180,3	191,5
transport, storage and communication	209,6	202,4	197,3	194,0
financial intermediation	110,7	114,3	117,9	121,8
real estate, renting and business activities	310,7	355,6	401,6	456,4
public and private services	921,6	966,4	1015,7	1066,2

Table 3: Overview of results of the scenario “Aachen I” for the years 2010 and 2020, as deviation from the baseline scenario (in %)

Scenario „Aachen I“ Deviation from baseline scenario			
	Unit	2010	2020
Total Economy:			
GDP (real)	in %	7,2	24,5
consumption by households (real)	in %	6,4	20,9
export (real)	in %	1,9	6,9
import (real)	in %	-2,5	-5,6
price index GDP	in %	-3,9	-12,4
employees (national concept)	in %	0,9	2,4
thereof:			
agriculture, hunting, forestry	in %	-0,8	0,6
mining and quarrying	in %	-0,3	1,0
manufacturing	in %	-1,9	-6,0
electricity, gas, water supply	in %	-1,1	-5,5
construction	in %	0,1	2,5
wholesale, retail trade; repair of motor vehicles and personal goods	in %	0,1	0,3
hotels, restaurants	in %	3,2	8,9
transport, storage and communication	in %	-0,9	-1,9
financial intermediationFINANCIAL INTERMEDIATION	in %	0,3	0,7
real estate, renting and business activities	in %	5,4	7,6
public and private services	in %	1,6	5,9
disposable income of private households	in %	3,5	10,6
Environment:			
material input (total)	in %	-7,8	-17,8
material imports	in %	-10,8	-23,2
domestic extraction	in %	-5,8	-14,0
material productivity (total;GDP related to DMI)	in %	16,3	51,5
domestic extraktion	in %	13,8	44,7
material imports	in %	20,2	62,1
construction	in %	16,8	60,0

Table 4: Overview of results of the scenario “Aachen II” for the years 2010 and 2020, as deviation from the baseline scenario (in %)

Scenario „Aachen II“ Deviation from baseline scenario			
	Unit	2010	2020
Total Economy:			
GDP (real)	in %	0,1	0,3
consumption by households (real)	in %	0,1	0,2
export (real)	in %	0,0	0,1
import (real)	in %	0,0	-0,1
price index GDP	in %	-0,1	-0,2
employees (national concept)	in %	0,0	0,0
thereof:			
agriculture, hunting, forestry	in %	-0,2	-0,9
mining and quarrying	in %	-0,2	-0,4
manufacturing	in %	0,0	0,0
electricity, gas, water supply	in %	0,0	-0,1
construction	in %	0,0	0,2
wholesale, retail trade; repair of motor vehicles and personal goods	in %	0,0	0,0
hotels, restaurants	in %	0,0	0,1
transport, storage and communication	in %	0,0	0,0
financial intermediationFINANCIAL INTERMEDIATION	in %	0,0	0,0
real estate, renting and business activities	in %	0,0	0,0
public and private services	in %	0,0	0,1
disposable income of private households	in %	0,0	0,1
Environment:			
material input (total)	in %	-0,9	-2,9
material imports	in %	-0,5	-1,7
domestic extraction	in %	-1,2	-3,7
material productivity (total;GDP related to DMI)	in %	1,0	3,2
domestic extraktion	in %	1,3	4,1
material imports	in %	0,6	2,1
construction	in %	1,7	5,5

Table 5: Overview of results of the consumption scenario for the years 2010 and 2020, as deviation from the baseline scenario (in %)

„Consumption scenario“ Deviation from baseline scenario	Unit	2010	2020
Total Economy:			
GDP (real)	in %	-1,8	-5,4
consumption by households (real)	in %	-0,3	-10,5
export (real)	in %	0,0	0,1
import (real)	in %	-1,1	-2,7
price index GDP	in %	0,3	0,6
employees (national concept)	in %	-0,5	-1,6
thereof:			
agriculture, hunting, forestry	in %	-0,6	-2,0
mining and quarrying	in %	-0,2	-0,8
manufacturing	in %	0,1	0,9
electricity, gas, water supply	in %	0,3	2,2
construction	in %	-1,3	-4,8
wholesale, retail trade; repair of motor vehicles and personal goods	in %	-0,4	-1,5
hotels, restaurants	in %	-1,6	-4,7
transport, storage and communication	in %	0,1	0,3
financial intermediationFINANCIAL INTERMEDIATION	in %	-0,3	-0,7
real estate, renting and business activities	in %	-1,1	-2,9
public and private services	in %	-0,5	-1,9
disposable income of private households	in %	-1,4	-4,8
Environment:			
material input (total)	in %	-0,9	-2,5
material imports	in %	-0,7	-2,2
domestic extraction	in %	-0,9	-2,8
material productivity (total;GDP related to DMI)	in %	-0,9	-2,9
domestic extraktion	in %	-0,9	-2,7
material imports	in %	-1,1	-3,3
construction	in %	-1,0	-3,1

Table 6: Development of GDP, employment and wages (deviation from baseline scenario in%)

	2010	2015	2020
GDP	-0,20	-0,40	-0,44
Employees	0,33	0,66	1,09
Compensation of Employees	0,33	0,65	1,24

Table 7: Labour demand and supply for different qualification levels (in 1000 persons)

	Unemployed per qualification	Employees per qualification	Employees per qualification
in 1000 Personen	**2005**	**2005**	**2020**
Elementary school	89,08	692,28	747,06
Apprentice training, Lower secondary schools	103,91	1597,91	1695,43
Secondary academic schools	15,31	160,47	177,85
Secondary technical and vocational education	15,31	290,07	324,66
College, education for teachers	8,14	198,54	214,21
Universities, vocational universities	16,16	260,61	309,54
Total	250,60	3199,89	3468,75

Table 8: Overview of results of the scenario "working time reduction" for the years 2010 and 2020 as deviation from the baseline scenario (in %)

„Working time reduction" **Deviation from baseline scenario**			
	Einheit	**2010**	**2020**
Total Economy:			
GDP (real)	in %	-0,2	-0,4
consumption by households (real)	in %	-0,1	0,4
export (real)	in %	-0,1	-0,3
import (real)	in %	0,1	0,4
price index GDP	in %	0,3	1,2
employees (national concept)	in %	0,3	1,1
thereof:			
agriculture, hunting, forestry	in %	0,3	1,1
mining and quarrying	in %	0,9	3,7
manufacturing	in %	0,4	1,2
electricity, gas, water supply	in %	0,8	2,8
construction	in %	0,3	1,3
wholesale, retail trade; repair of motor vehicles and personal goods	in %	0,5	1,4
hotels, restaurants	in %	0,3	1,7
transport, storage and communication	in %	0,4	1,3
financial intermediationFINANCIAL INTERMEDIATION	in %	0,6	2,0
real estate, renting and business activities	in %	0,3	1,2
public and private services	in %	0,1	0,5
disposable income of private households	in %	0,2	1,5
Environment:			
material input (total)	in %	-0,1	0,2
material imports	in %	0,0	0,3
domestic extraction	in %	-0,1	0,1
material productivity (total;GDP related to DMI)	in %	-0,1	-0,6
domestic extraktion	in %	-0,1	-0,5
material imports	in %	-0,2	-0,7
construction	in %	-0,1	-0,4

Figures:

Figure 1: Structure of the model e.3.at

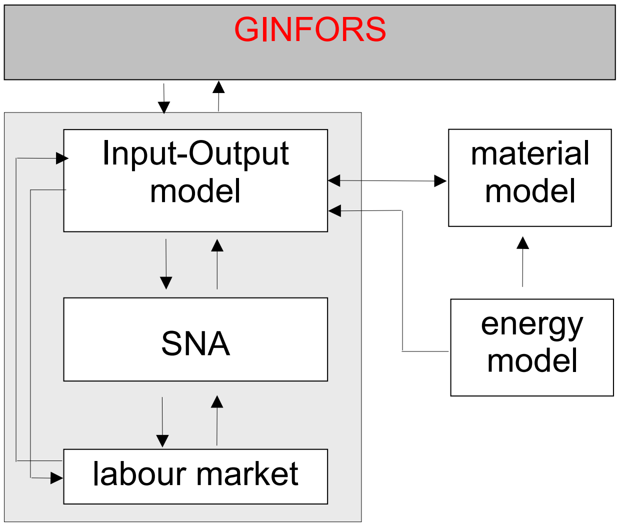

Figure 2: Overview of material inputs, covered by the material module

	Domestic Extraction	Material imports
Biomas	food feed animals foresty non edible biomass	food feed animals foresty non edible biomass
Minerals	construction minerals industrial minerals ores	construction minerals industrial minerals ores
Fossil fuels	coal crude oil natural gas other fossils	coal crude oil natural gas other fossils

Figure 3: Absolute and relative development of GDP (baseline scenario)

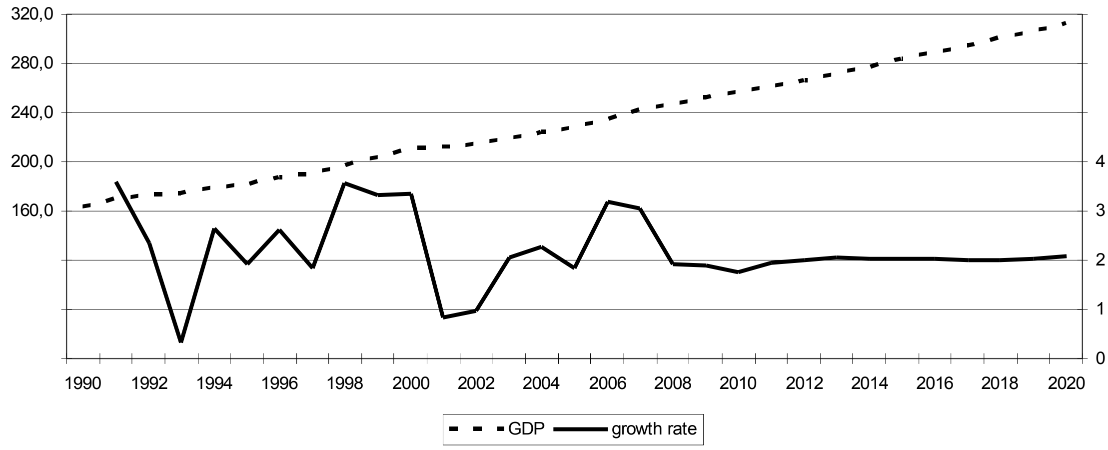

Figure 4: Absolute and relative development of employment (baseline scenario)

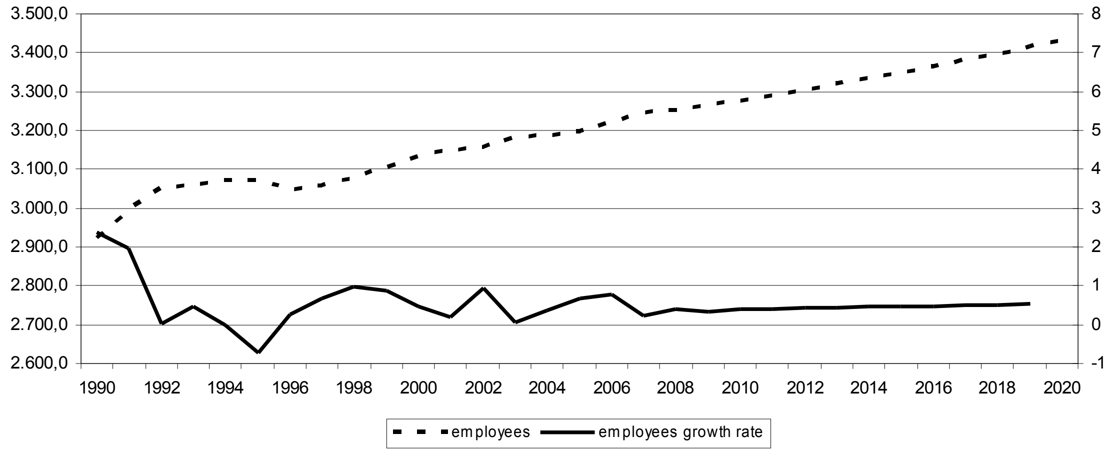

Figure 5: Absolute and relative development of material inputs (baseline scenario)

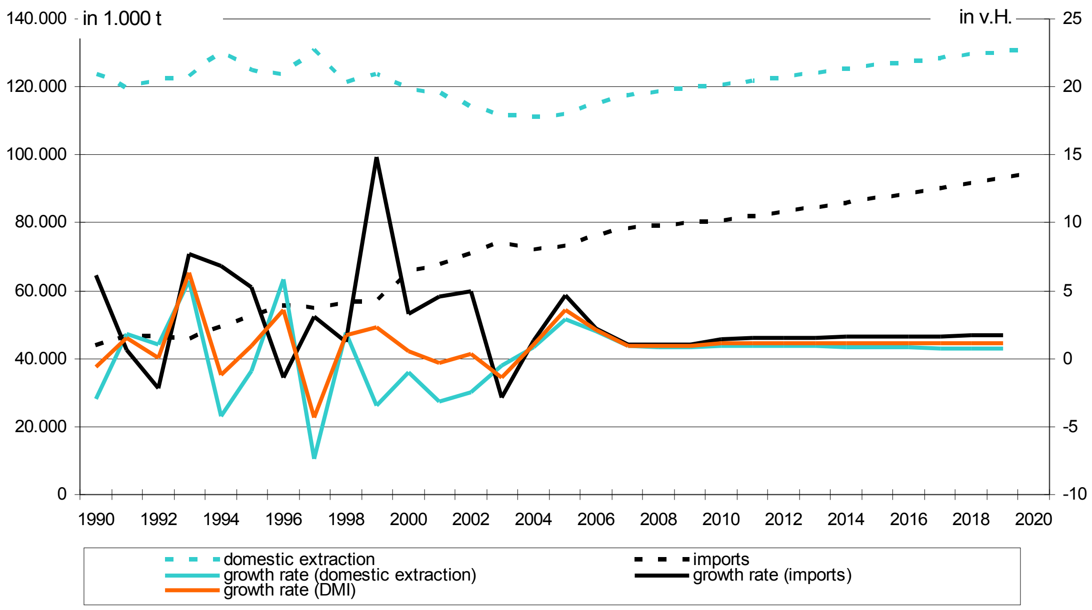

Figure 6: Development of material productivity (baseline scenario)

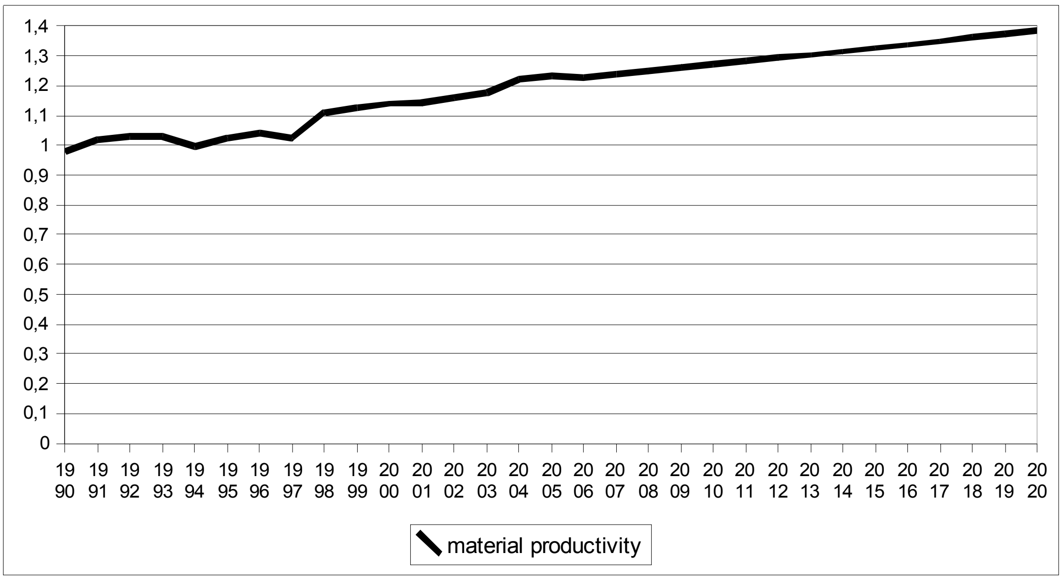

Figure 7: Relative deviations of GDP and material input compared to the baseline scenario (in %)

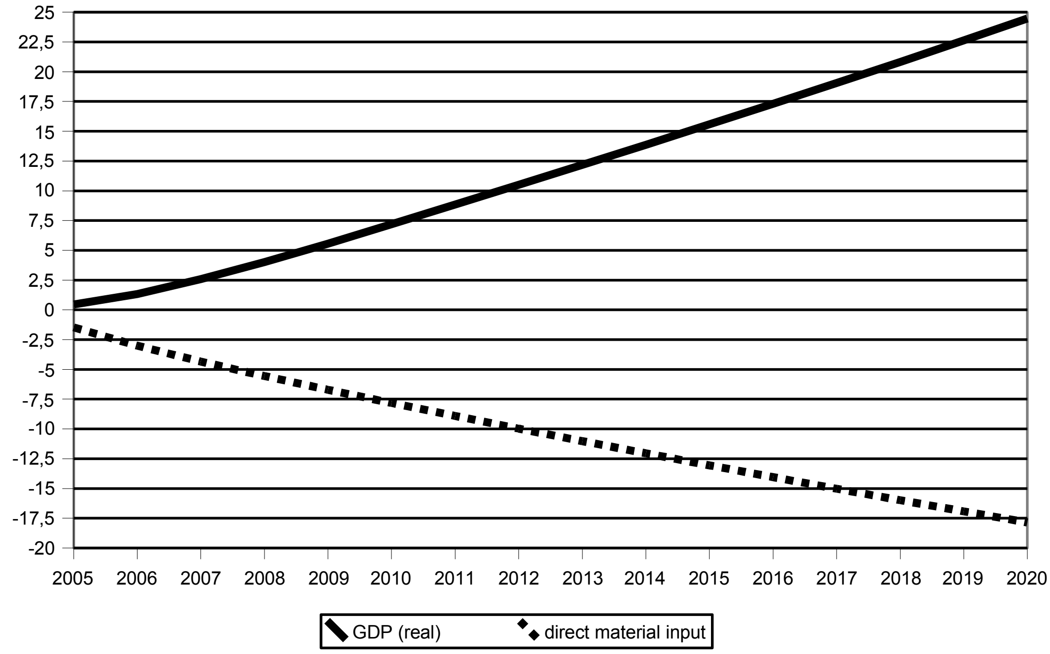

Figure 8: Development of material inputs (in 1000 tons)

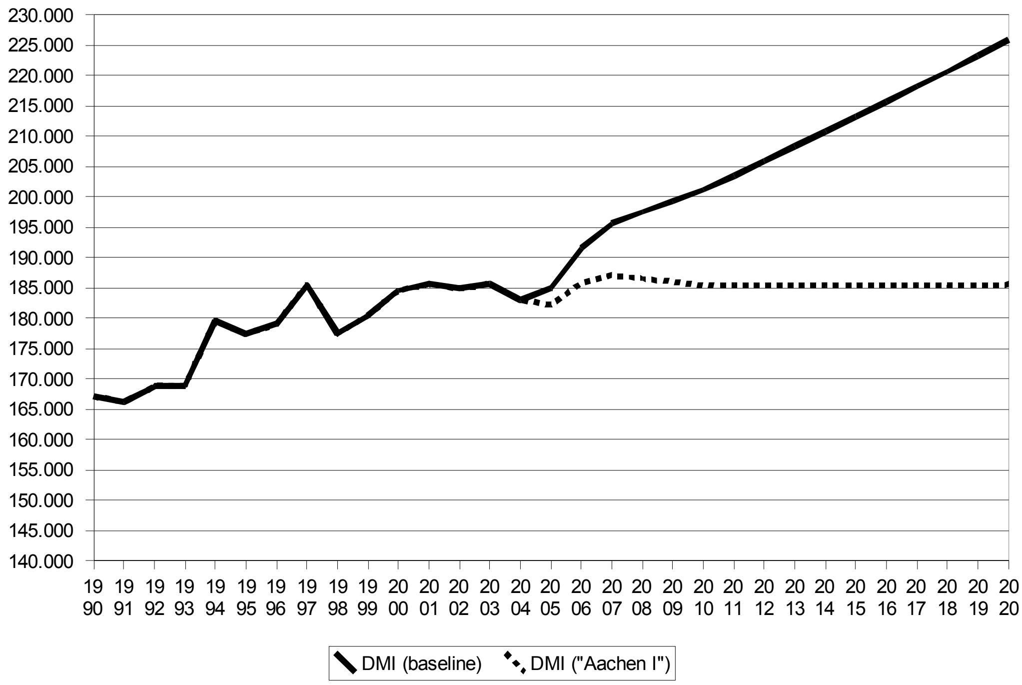

Figure 9: Development of private consumption (in billions EUR)

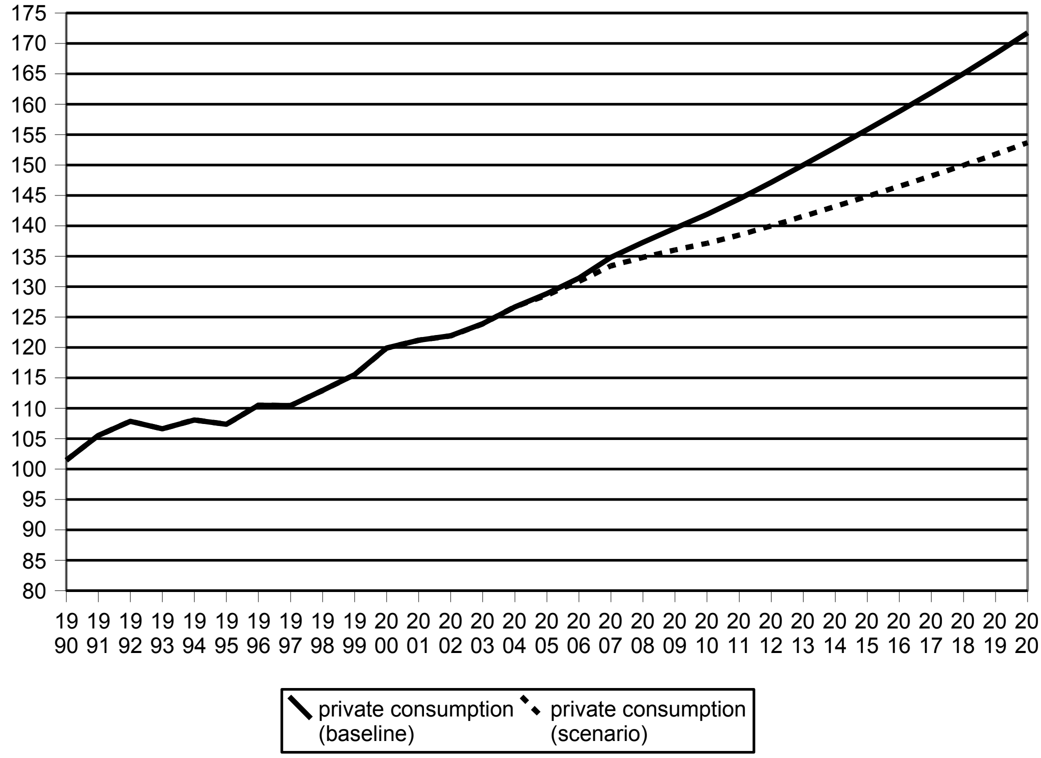

Figure 10: Development of GDP and material input (deviations from baseline scenario in %)