Economic impacts of the Energy Efficiency Directive - regional CGE approach

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Abstract

This study assesses the economic effects of the EU Energy Efficiency Directive (EED) in Finland at national and regional levels. Indicative target is to reduce the final energy consumption to 310 TWh by 2020. Our study concentrates on real estate sector that is the main target of the policy and comprises notable part of national economy.

We base our analysis in two models: a real estate sector model (REMA) and a single country regional CGE model (VERM). We found that even without considering productivity improvements, the EED implementation is cost-effective. Measures that improve energy efficiency impose constraints on technology that decrease economic efficiency. However, the increased investment activity more than compensates the loss.

The real estate sector carbon emissions decrease consistently over the time period. The total emissions decrease less than targeted because of the rebound effect. The EED also contributes to the other pillars of the EU climate policy. As the emission reduction yields modest economic growth with EED, it is a cost-efficient alternative for other climate policies.

The regional effects are mixed. The regional value added change is positive at each region. The employment increases more than proportionally in regions that produce materials for construction industry. Thus, the EED slightly decreases regional disparities.

Repayment of renovation debt is problematic because it allocates the renovation investments up front that generates unbalanced growth path. The period of repayment requires massive amount of investment that partially consumes the need for subsequent investments. Consequently during the repayment phase lots of additional capacity is generated. Subsequently that capacity becomes hard to employ and slows down the economic growth.

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Introduction

The EU Energy Efficiency Directive (EED) is part of the EU climate change policies. Its overall target is to improve energy efficiency by 20% by 2020. The directive came into effect in 2012 and by June 2014 it was to be implemented by the member states. It is the last of the three pillars of the EU climate change policy for 2020 to be implemented. The other two are 20% decrease in carbon emissions and increase of renewable energy share to 20%. Arguably the composition of the three policies was not clearly thought out as their interconnections had unforeseen and unwanted consequences. E.g. low EU ETS carbon prices and renewable mandates favored consumption of most polluting non-renewable energy while undermining some transitional less polluting fuels. It is therefore questionable whether the policy mix mitigates the climate change cost efficiently.

Consistent policy analysis ideally prevents implementation of non-optimal policy mixes. The policies aiming to energy efficiency improvement potentially have inconsistencies that need to be investigated. Energy efficiency improvement decreases energy demand which affects the other aspects of the climate policy such as promotion of renewables. Above all the efficiency improvements affect the real estate sector that is characterized by long-lasting and immobile capital stock. Regional population forecast is an important determinant of policy design. It nevertheless has uncertainties. The net out-migration regions typically have extra capacity in real estate that is economically not sensible to maintain. Thus, the long-run uncertainties and regional dynamics have implications to the policy design.

We examine the EED implementation in Finnish real estate sector and its effects on economy and climate change policies. Each member state set their indicative target. Finland set itself to reduce its final energy consumption to 310 TWh by 2020 that is 20% less than in 2008. The national economic effects could be significant as the real estate sector has focal role in the economy. In 2013 81% of the total gross capital stock and 55% of the investments were in real estate sector, of which half in residential buildings. Furthermore, the real estate heating constituted 25% of total energy end use.

The previous analyses (e.g. UKERC 2007) on energy efficiency improvement have concentrated on so called rebound effect. The rebound effect occurs when part of the emission reduction at the targeted sector is nullified when energy demand in the other sectors adjusts to new efficiency level. This essentially assumes that technologies that are both energetically and economically efficient already exist. In that situation energy efficiency improvement would lead to lower prices, which would induce more energy consumption and thus a “rebound”. It is however questionable why such technologies are not used in absence of particular policies. Economic theory tells that with perfectly functioning markets this should not happen. Although there are various reasons why markets do not always work perfectly, it is nevertheless questionable whether that would be a factor in our case. In renovation business there operates sufficiently many firms so that we can approach the situation as that of a perfect competition.

Our case extends long to the future and consequently involves considerable amount of uncertainty. Critical point of uncertainty is in endogenous technological change in general and in learning-by-doing process in particular. If we suppose that some of the technologies that the EED imposes are relatively new, there could be subsequent efficiency gains when new information of their use accumulates. In construction, however, learning-by-doing presents smaller opportunity than in many other cases because the created capital stock is long-lasting. Another aspect of productivity improvement comes from the use value of infrastructure in general. Newer and better maintained infrastructure facilitates use of other resources. For instance, renovation of schools that have mildew problems have potential productivity gains when the pupils can spend more time learning and less time burdening public health care services.

We deviate from previous studies that consider productivity improvements with some certainty and consider policies aiming at energy efficiency improvements as essentially restrictions to implementable technologies. As the resulting total productivity improvements are tentative and vague, we see it inappropriate to have it as a defining element in our analysis. Rather we pose the question of economic sensibility of such policies in terms of required total productivity improvement that would make the policies also economically sensible. The potential emission reductions add to desirability of such policies and cost efficiency when compared to other means should be taken as the indicator for sensibility in climate policy terms.

We use two economic models in our analysis: a real estate sector model (REMA) and a single country regional CGE model (VERM). The REMA model is developed at VTT Technical Research Centre of Finland for detailed analysis of real estate sector. It has recently been extended with regional dimension that allows NUTS2 level regional breakdown. The VERM model is developed at VATT Institute for Economic Research and it is a general purpose CGE model developed to answer various policy questions that have regional dimension. The modeling sequence starts with REMA, which results determine the real estate and construction sector development in VERM simulations. We frame our study with three scenarios: base, policy and renovation debt repayment. The base scenario incorporates REMAs no-EED prediction into VERM baseline. The policy scenario alters the base scenario by including EED effects on real estate investment and fuel demand. Additionally, we consider an alternative scenario that is a more extreme case that represents more ambitious policy goal by portraying full repayment of the real estate sector renovation debt.

We present our research in following sequence. First, we discuss the data and its application in the models. Then, we explain the basic features of the REMA model and present the main results on construction and real estate sectors. We then proceed to VERM model and its main results on national and regional economies. Then we discuss the results and finally give the conclusions.

Material and methods

This chapter describes the data and the process for modifying it for compliance between the models. In general, REMA database has more detail in real estate sector than VERM. On the other hand VERM has more extensive description of national economy by its underlying input/output structure. VERM database is also malleable and we constructed a special industry commodity classification for this study.

REMA database

The REMA model (Vainio et al., 2012) database has NUTS 2 regional breakdown that includes four regions: Helsinki-Uusimaa, South Finland, West Finland, and East-North Finland[1]. Regional distribution of the building stock is relatively even at this level. The most significant difference is that the separate one-family houses are predominantly located at West and East-North Finland whereas row houses and apartment buildings are more dominant in Helsinki-Uusimaa and South Finland. This discrepancy is predicted to

[1] NUTS 2 regional classification also includes an autonomous region of Åland islands. We have excluded Åland from our study because it implements the EED independently. Åland comprised 0.5% of Finnish population and 0.65% of GDP in 2013. We did not omit Åland from VERM calculations, however.

become more pronounced as younger generations increasingly move to Helsinki-Uusimaa and South Finland.

Rema is a bottom-up model that uses representative building types for estimating the energy usage in different segments of the building stock. Future developments are estimated using annual rates of new construction, renovations and removals from the building stock. REMA also includes a simplified model of the energy sector allowing CO2 emission calculations.

The energy calculation is described in more detail by Tuominen et al. (2014). It is based on choosing a five representative building types and using their energetic properties to calculate the energy consumption. The results are combined to two sections: residential buildings and non-residential buildings. Moreover, building categories are divided into age groups: buildings constructed before 1959, during 1960-1979 and during 1980-2009. They represent distinct periods in the history of the Finnish building stock (Official Statistics of Finland: Buildings and free-time residences). For example the period 1960-1979 is timespan of mass urbanization and also timespan when building construction was industrialized. After the energy crises in the 1970's more attention was paid to insulation, airtightness and mechanical ventilation became more commonplace, meaning again a change in the makeup of the building stock.

Similarly, new buildings are assumed to have different properties depending on the time period when they will be constructed. The default values for the future time periods are 2010-2019, 2020-2029 and 2030-2050 because of EU and national climate and energy policies. One of EU policies is to have nearly zero-energy new buildings by 2020.

The volume of new building construction and renovation is tied to statistics (Official Statistics of Finland: Building and dwelling production). Values are in 2010 fixed prices. The extra cost derived from energy upgrading compared to quality level of the year 2010 has been studied by VTT in several projects (Airaksinen & Vainio, 2012; Vainio et al., 2012).

The demand for new residential buildings is driven by the Statistics Finland population forecast. The demand for services buildings has the same driver and historically determined multipliers. The population forecast is regional and includes internal migration. Although the forecast has thus far predicted strong migration from peripheries (especially East-North Finland) to the center (Helsinki-Uusimaa) the actual migration has been stronger.

Time steps of REMA and VERM differ: REMA's results are for years 2010, 2020, 2030 and 2050, whereas VERM has yearly steps from 2008 to 2040. In order to reconcile this discrepancy, we applied geometric growth rates for the intermittent years. We also omitted the year 2050 results from VERM calculations.

VERM database

The regular VERM database and the corresponding baseline have more detailed NUTS 3 regional classification, which we aggregated to NUTS 2 level. The model has 39 industries and 48 commodities, which is in general more aggregated than in basic setting of 49 industries and 55 commodities. However, the construction industry and its main commodities have more detail than in the regular VERM setting. We needed this disaggregation because REMA results show divergence in demand for new buildings and renovation. The construction industry is divided into construction of new buildings and renovation. The commodities are first divided into residential and non-residential buildings. Both residential and non-residential buildings are further divided into construction of new buildings, basic renovation and yearly renovation. Basic renovations are long term and interpreted as investments whereas the yearly renovations are intermediate inputs. The energy efficiency improvements belong to the former category.

We impose the REMA's results in the VERM real estate sector trajectory. The commodities of construction sector are used as investments in real estate sector. Thus the REMA's results for construction activity volumes serve as real estate sector investments in VERM. The REMA's results for energy efficiency improvement serve as real estate sector's demand for energy commodities in VERM. REMA's energy demand is in GWhs and we straightforwardly interpret that as a volume change in intermediate energy demand.

Real estate sector and EED – REMA model analysis

Airaksinen & Vainio (2012) used REMA to calculate the real estate sector energy demand scenarios for the Ministry of Environment. The scenarios varied by the extent of renovation and fulfillment of EED standards. In our study the results were broken down to NUTS 2 regional classification. Additionally, we calculated a more extreme scenario that portrays the repayment of real estate sector renovation debt in ten years (2010-2020). The Finnish buildings stock is eroding due to insufficient maintenance as renovation investments have not been sufficient to cover the depreciation.

Scenarios

In the base scenario, the cost structure of housebuilding is kept at pre-2010 level. New construction is subject to the energy efficiency requirements that came into effect in 2010. The requirements improved the energy efficiency by 20% and increased investment costs by 10%. However, no energy efficiency requirements apply to renovations.

In the policy scenario, new construction is subject to the same requirements as in the base scenario. Additionally, the energy efficiency requirements that came into effect in 2013, affect the renovation costs, which only apply to licensed renovations. We assume that the requirements do not increase the amount of renovation work, just the cost of renovation that would have been required regardless.

In the renovation debt repayment scenario, the quantity, structure and cost of new construction remains the same as in the policy scenario. In addition renovation activity increases to reflect the actual need. Historically, housing stock has accumulated renovation debt due to neglect. The estimated amount of renovation debt is 30 billion euros of which 20 billion euros apply to residential buildings and the rest to non-residential buildings. We assume that the renovation debt is paid within 10 years. Hence, in the repayment scenario, renovation comprises renovation work dictated by a need for renovation and for paying the renovation debt.

In all three scenarios, the value of construction equals the output value, including both the added value of housebuilding, i.e. the work done on-site, and the use of intermediate inputs, i.e., the construction materials, and services purchased at construction sites.

The initial position is the base scenario and its inspection time, 2010. The second and third scenarios and the later inspection times are tied to it. The initial position, i.e. the values of new construction and renovation, are from the Official Statistics of Finland (OSF). The additional costs of the second and third scenarios are based on the cost-effect estimates associated with the preparation of the cost efficiency regulations.

Results

Figure 1 and Figure 2 summarize the changes in new buildings construction and renovation, respectively. At the base scenario (BASE) the volume of new buildings construction diverges between the regions while the overall decrease is 6.1%. The regional extremes are Helsinki-Uusimaa with 21% increase and East-North Finland with 33% decrease. Renovation activities decrease 15% at each region. In the policy scenario (EED) both forms of construction activities increase. At the national level the new buildings construction increases by 6% while renovation decreases by 10%. The disparities in new buildings construction remain: Helsinki-Uusimaa grows by 36% while East-North Finland contracts by 10%. In the renovation debt repayment scenario (CDR) the renovation activity increases strongly during the repayment period, but gradually declines after that. The national renovation activity nearly triples by 2020 (160% increase) and ends up at almost double of the initial level by 2030 (80%). Renovation activities increase slightly more in peripheries (185% in East-North Finland) than in Helsinki-Uusimaa (142%) by 2020 after which all the regions settle to 80% by 2030.

Figure 3 summarizes the changes in real estate sector energy consumption. The real estate sector energy demand decreases by 11% at the national level in the base scenario. It decreases least in Helsinki-Uusimaa (7.6%) and almost equal amount in rest of the regions (11-12%). In the policy scenario the real estate energy demand decreases further, reaching 15% reduction by 2030. Regional disparities remain: 12% decrease at Helsinki-Uusimaa and 15-16% decrease at the rest. Increased renovation activity in the repayment scenario decreases real estate sector energy demand by 16% at the national level. The reduction happens predominantly at the peripheral regions. Figure 4 shows carbon emissions at the real estate sector. The emissions decrease in both the policy and repayment scenarios. The national emission reduction in the policy scenario is 4.4% by 2030 and 6.4% by 2050. Debt repayment decreases emissions slightly more: 5.9% by 2030 and 8.5% by 2050. It should be kept in mind that the figures above apply to the real estate sector only. We will next cover the national and regional effects studied with the VERM model that apply to all of the sectors.

The effects on national and regional economies – VERM model analysis

This section summarizes the national and regional economic effects due to energy efficiency improvements in the policy and repayment scenarios. We present the VERM model results as cumulative percentage change deviations from the base scenario between 2010 and 2040.

Policy scenario

Figure 5 and Figure 6 summarize the main macro changes and price indices, respectively. New construction sector regulation imposes new energy efficient technology that needs to be adopted in the sector. However, this regulation constrains the firms to adopt more expensive technology than before which leads to increased costs. On the other hand increased investment activity is likely to have positive effects and the relation of these two forces define the actual national economic outcome of the policy. In addition we need to consider the emission reduction goals and cost efficiency of achieving them with energy efficiency regulations.

The policy requires additional investment that initially accumulates capital stock. After the investments subside and ends up lower than in the baseline after 2020. Household consumption increases during the whole period. Imports decrease due to lower demand for energy. In overall, our calculations show that the EED implementation has a small positive effect on the national value added. Yearly increase is minuscule

0.01%. Nevertheless our assumptions being conservative for induced technological change, we can quite safely say that the EED has positive effects on the national economy. Increased investment demand is enough to overcome costs of less efficient energy technology.

The import volume naturally decreases as significant part of the saved energy is imported. The export volume decreases nevertheless more because the increased investment demand at domestic markets replaces some of the exports. The terms of trade nevertheless improves somewhat. Real wages increase as the consumer price index depreciates.

Figure 7 and Figure 8 show the income and expenditure side decomposition of the value added, respectively. The bars depict weighted shares in total GDP change, which we depict by a line. At the income side the dominant feature is a notable increase in capital income, which follows directly from increased investment activity. The commodity tax income decreases along the decreasing consumption – the energy carriers comprise over proportionate share in commodity taxation. The only negative effect on the expenditure side is the exports which decline when much of the new investment commodities are domestically sourced.

Figure 9 and Figure 10 show the regional value added and employment effects, respectively. Regional differences are small, but the more remote regions (East and North Finland, Western Finland) that have higher share in construction material production grow more than other regions. Thus, EED slightly ameliorates regional disparities.

Figure 11 depicts the changes in energy consumption in main sectors of the economy. The blue line depicts the total fuel consumption change and the bars its sectoral breakdown. Very clear rebound effect can be seen. Fuel consumption only decreases in the real estate sector and the rest of the sectors are able to increase their consumption as the prices decrease and investment activity increases. The orange line shows the rebound effect (axis on the right), which starts low (~10%) but after longer time adjusts to quite high level (~40%).

Repayment of renovation debt scenario

Figure 2 made it evident that the Finnish real estate sector renovation debt has significantly accumulated; the 10 years repayment scheme implies that the renovation costs would more than double during the period. Nevertheless, our CGE analysis shows relatively modest economic effects.

The value added decreases, but moderately, slightly less than with the EED alone. Figure 12 and Figure 13 summarize the main macro changes and price indices, respectively. The required increase in investment activity is unrealistically high. Additionally, the repayment is done up front. That increases the value added initially, but immediately after the debt has been repaid, it ends up lower than the baseline. The funding of investments requires inhibiting household consumption as the resources are increasingly directed to investments. Afterwards less debt requires servicing and consequently investment levels drop. This scenario actually represents very unbalanced capital accumulation path and adjustment of the economy. The first ten years are increasingly active economically, but the remaining ten years reverse the trend. The real wages increase initially and follow the upward trend set by investments. Once the debt is repaid, the real wages start to settle and finally end up lower than in the baseline. The investment boom stokes up capacity, which will be at unnecessarily high level after the boom has passed. The jobs created for the renovation boom disappear abruptly.

Figure 14 and Figure 15 depict the income and expenditure side decomposition of the value added, respectively. At the income side we see the effect of rolling the investment up front as all the resources decrease their contribution after the repayment period. In the expenditure side the investment has big positive impact that cannot nevertheless counter the negative effect in the household consumption.

Figure 16 and Figure 17 show the regional value added and employment, respectively. As the debt repayment leads to more capital intensive structure of the economy, the employment is more negatively affected than in the EED scenario.

Conclusion

We have studied the effects of energy efficiency improvement and repayment of renovation debt with chain of two models, REMA and VERM. We deviate from previous energy efficiency studies by not assuming that the policy that is virtually a restriction of the feasible technology set would generate endogenous technological change. We also explicitly model the positive change in investment activity at quite detailed level. It is therefore natural that we find only modest economic gains from such policy. It should be noted that we do not find additional productivity improvement implausible. Rather, we suggest that our results indicate the lower bound of the productivity improvement that is required for the energy efficiency improvements to be profitable. Assessing the productivity improvement itself requires further investigation. However, we find that even with our conservative assumptions, the EED is economically feasible. At least at the current level it seems a cost efficient way to decrease emissions. Consistent comparison with the other climate change policies would shed more light. We also found that the rebound effect is quite strong and the initial emission reduction target of the policy is probably not achieved. More ambitious targets are required than static calculations would suggest.

The repayment scenario seems more problematic as it leads to much more unbalanced adjustment. Repayment of renovation debt in mere ten years requires huge increase in investments. After the renovation phase the investments will decrease below the base scenario. Resulting construction sector overcapacity slows down the whole economy.

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Figures

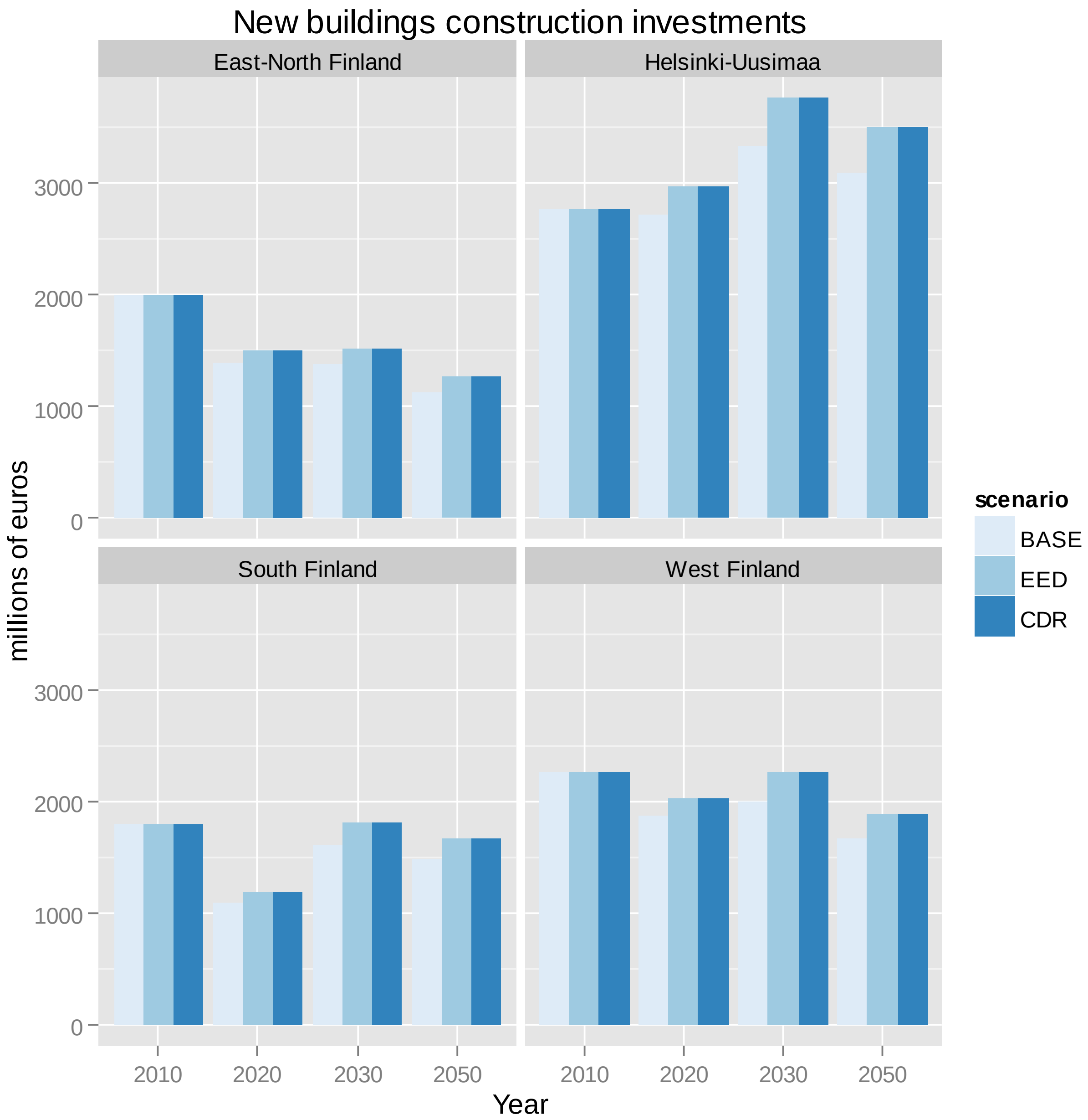

Figure 1. New buildings construction investments in all scenarios

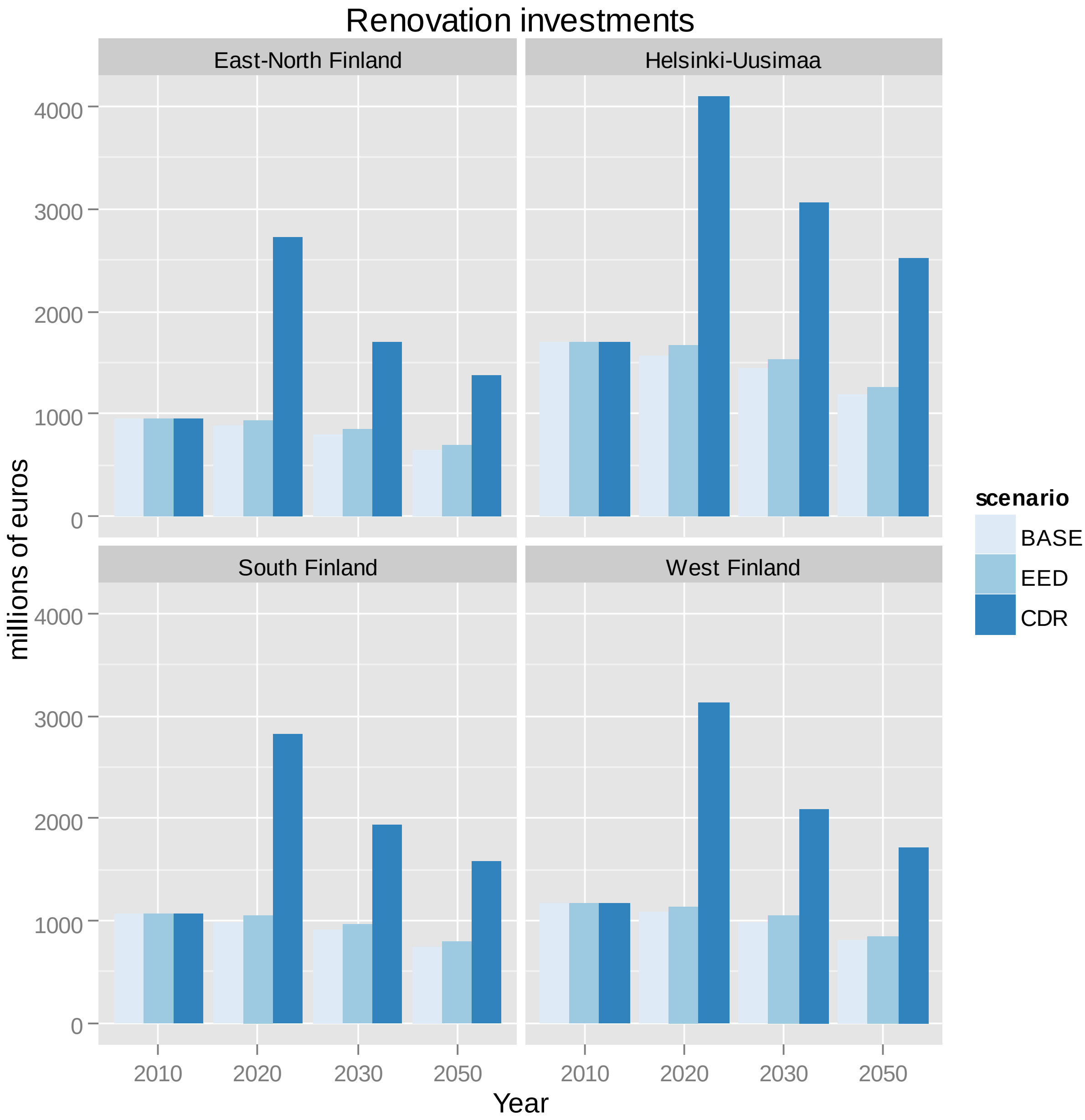

Figure 2. Renovation investments in all scenarios

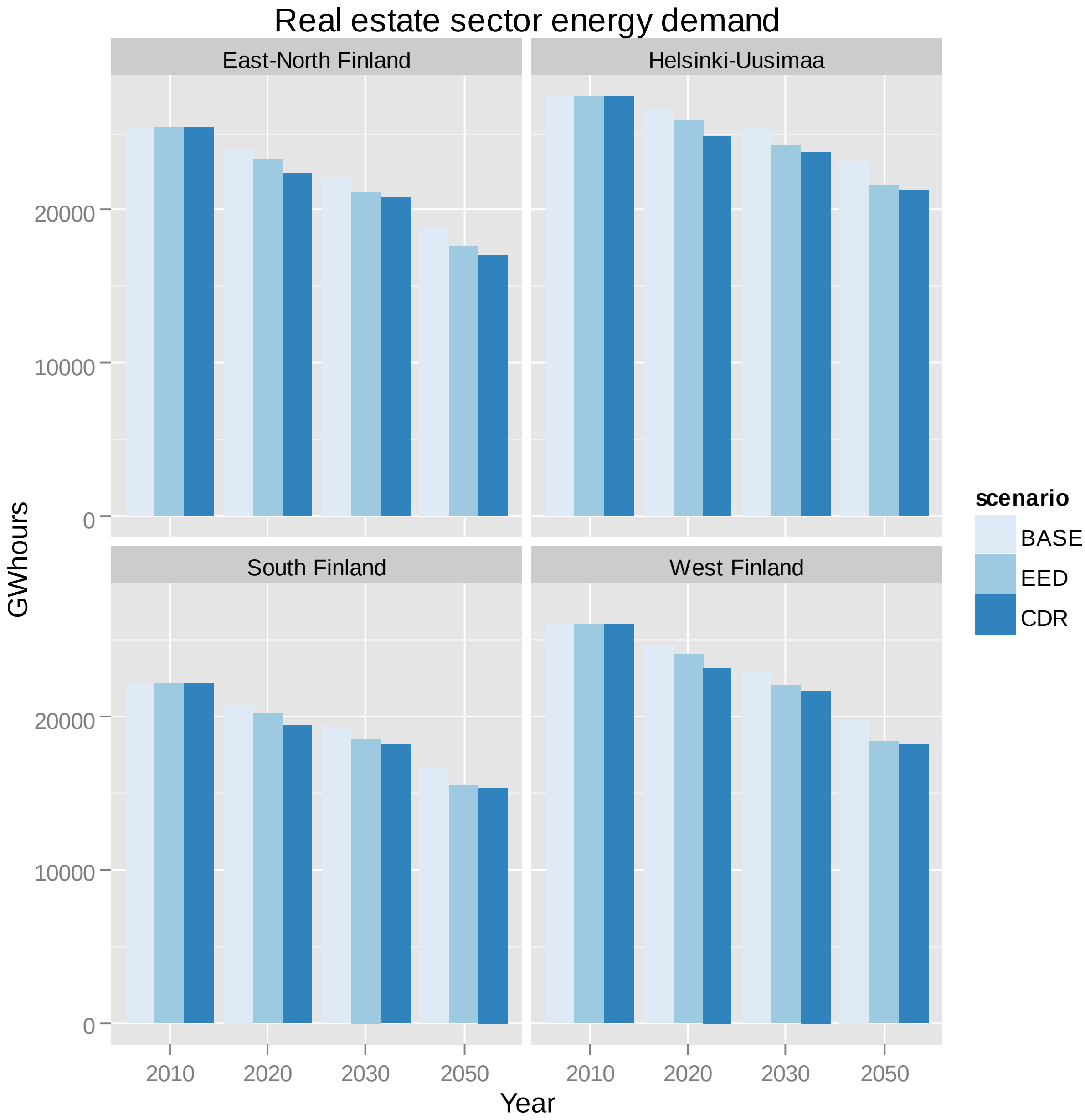

Figure 3. Real estate sector energy demand in all scenarios

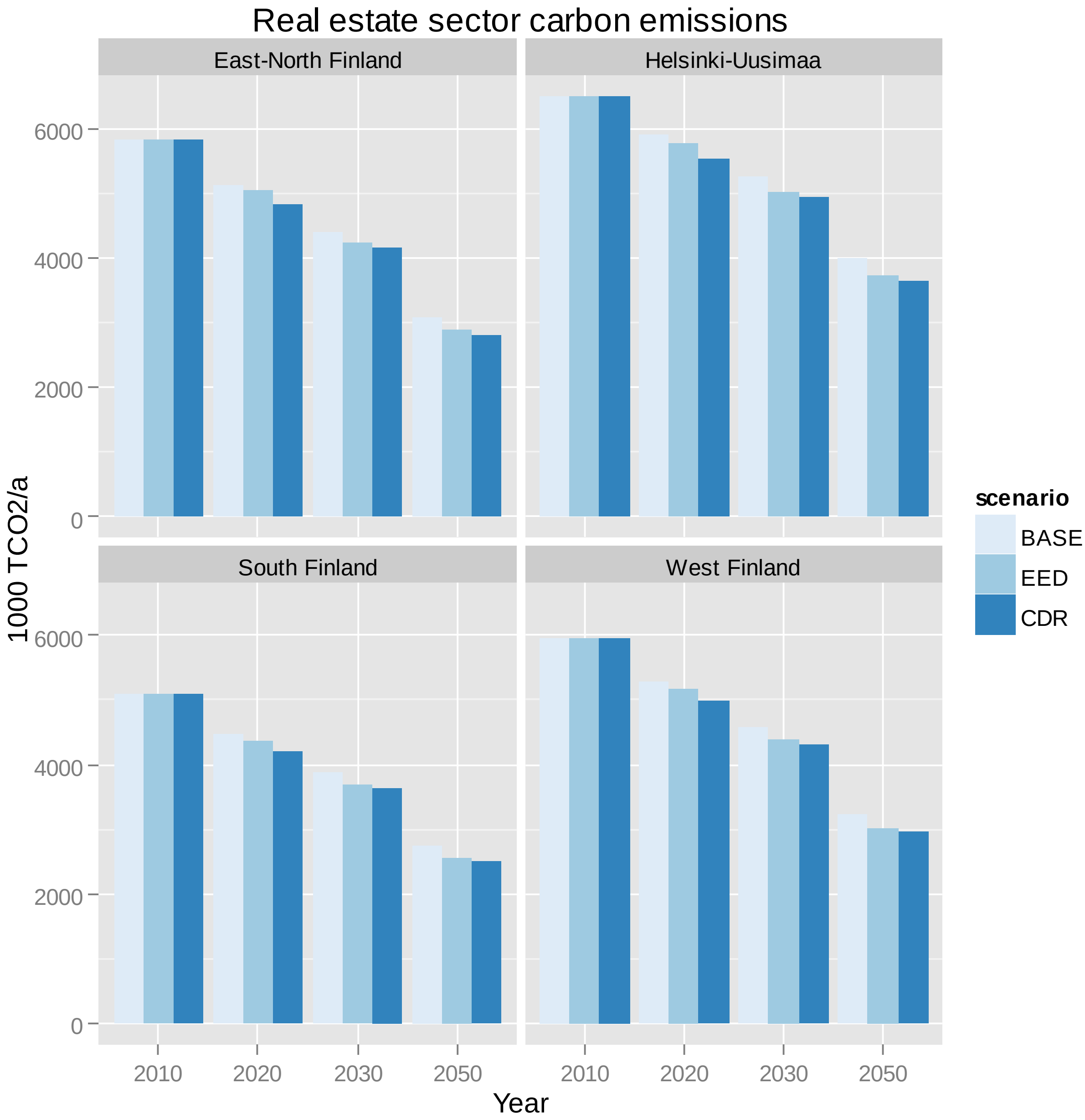

Figure 4. Real estate sector carbon emissions in all scenarios

Figure 5. Changes in macro variables (EED scenario)

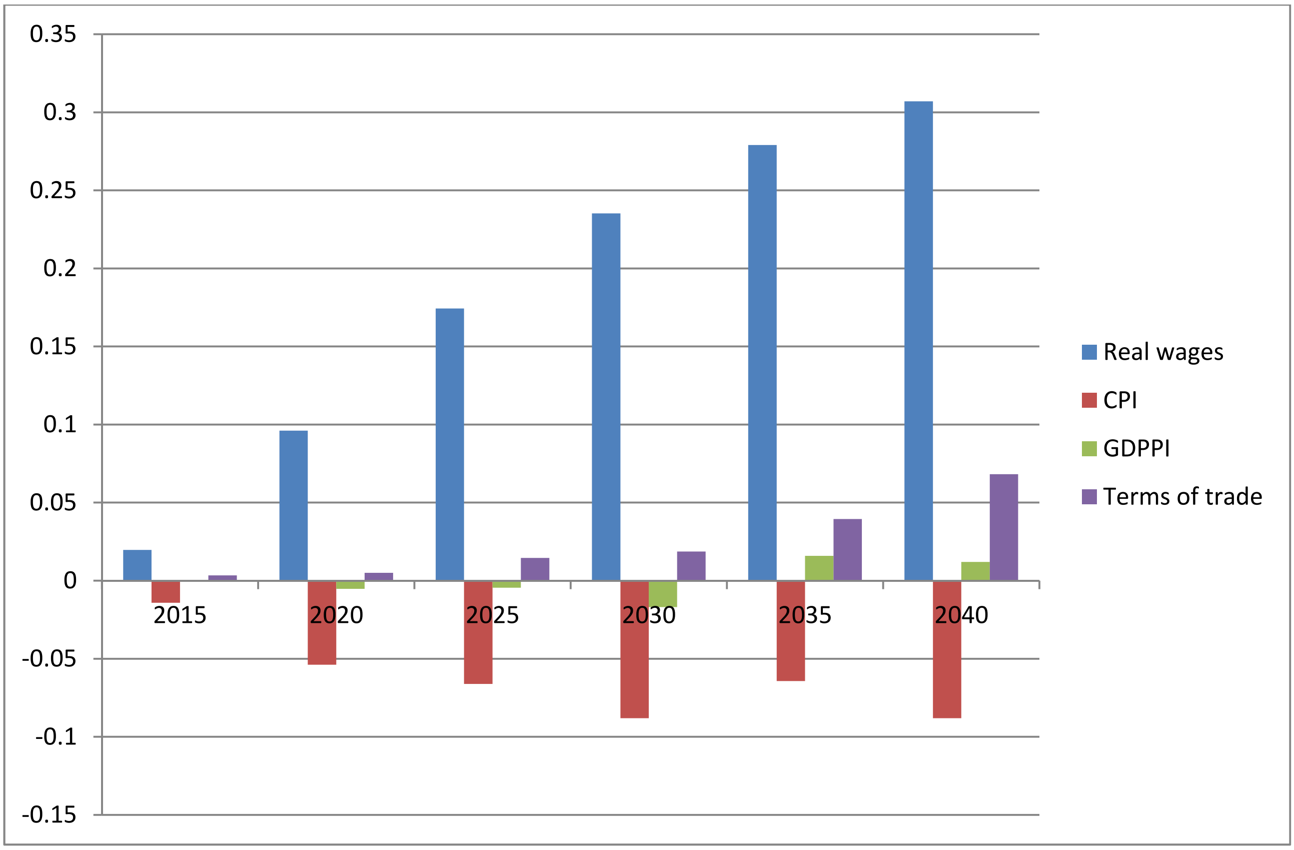

Figure 6. Changes in prices and indices (EED scenario)

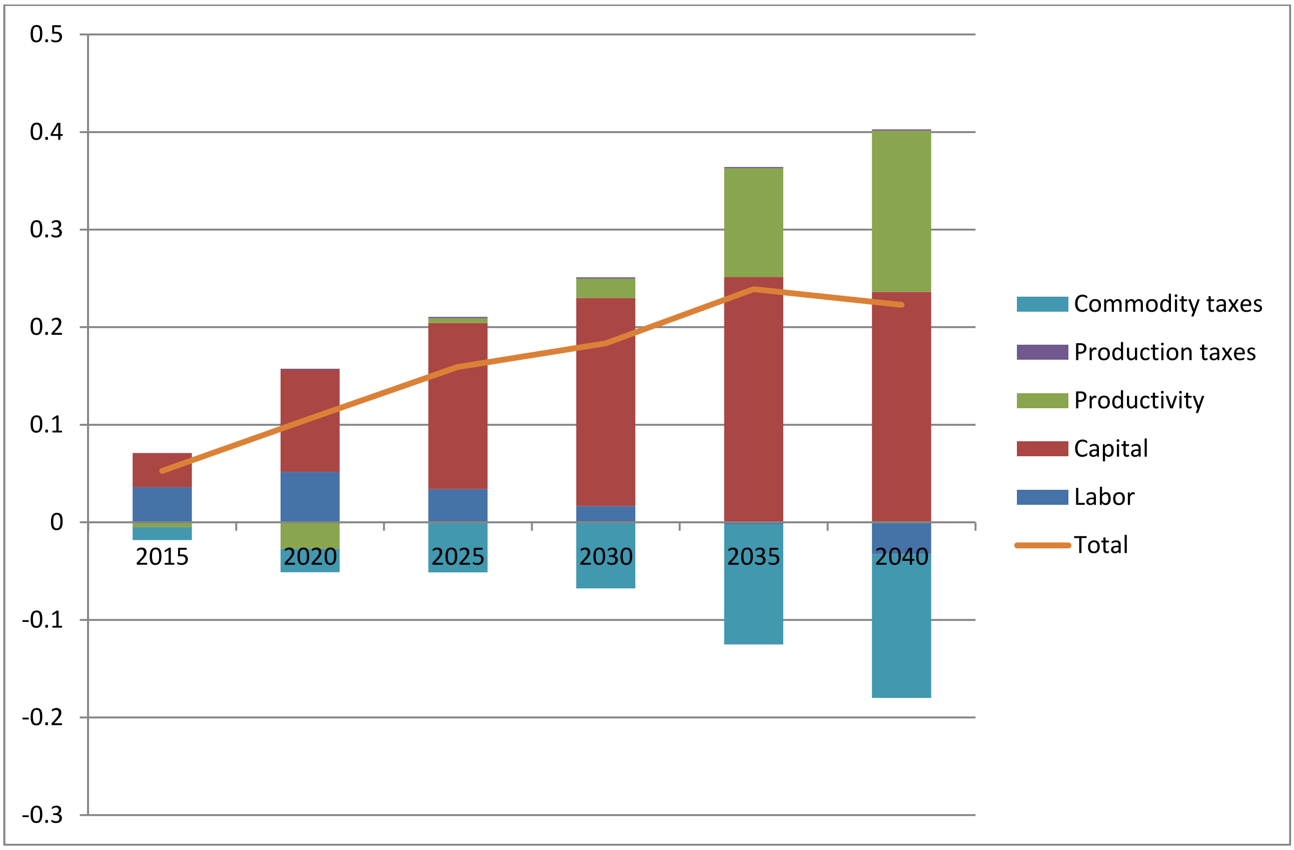

Figure 7. GDP income side decomposition (EED scenario)

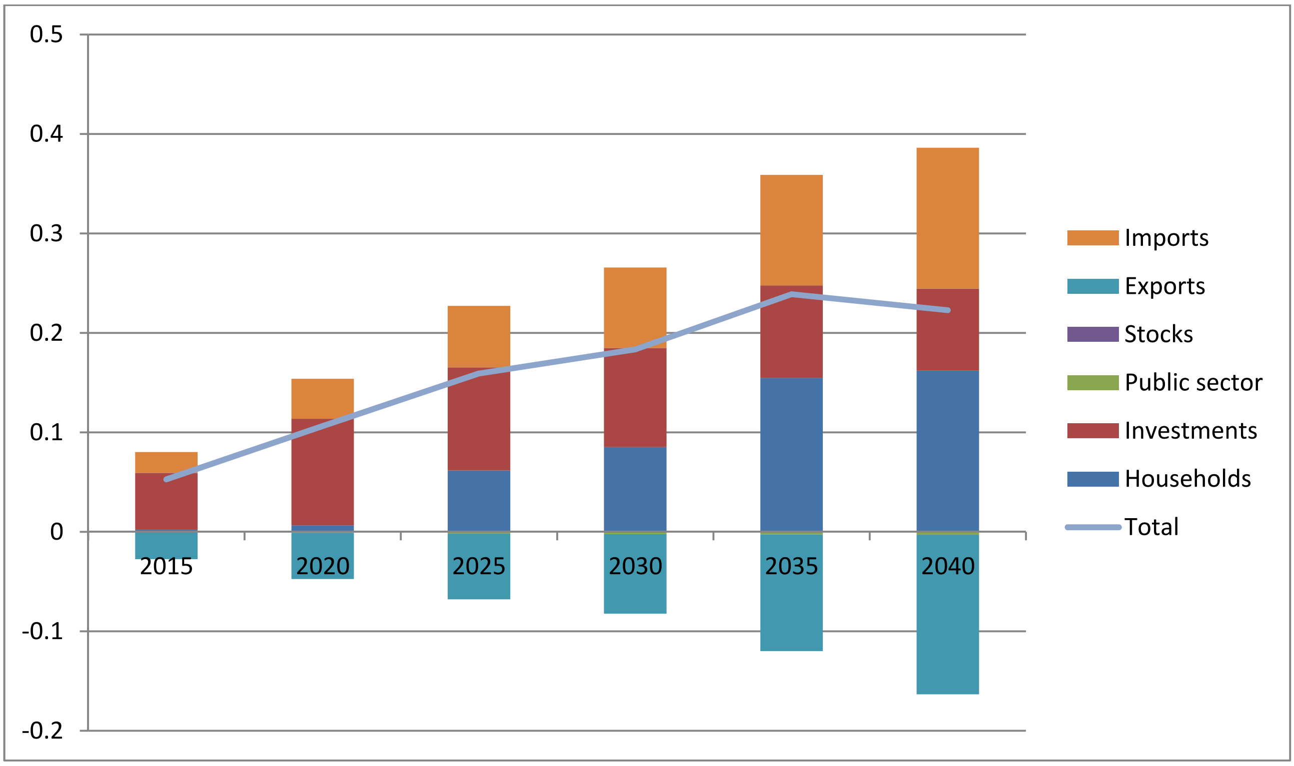

Figure 8. GDP expenditure side decomposition (EED scenario)

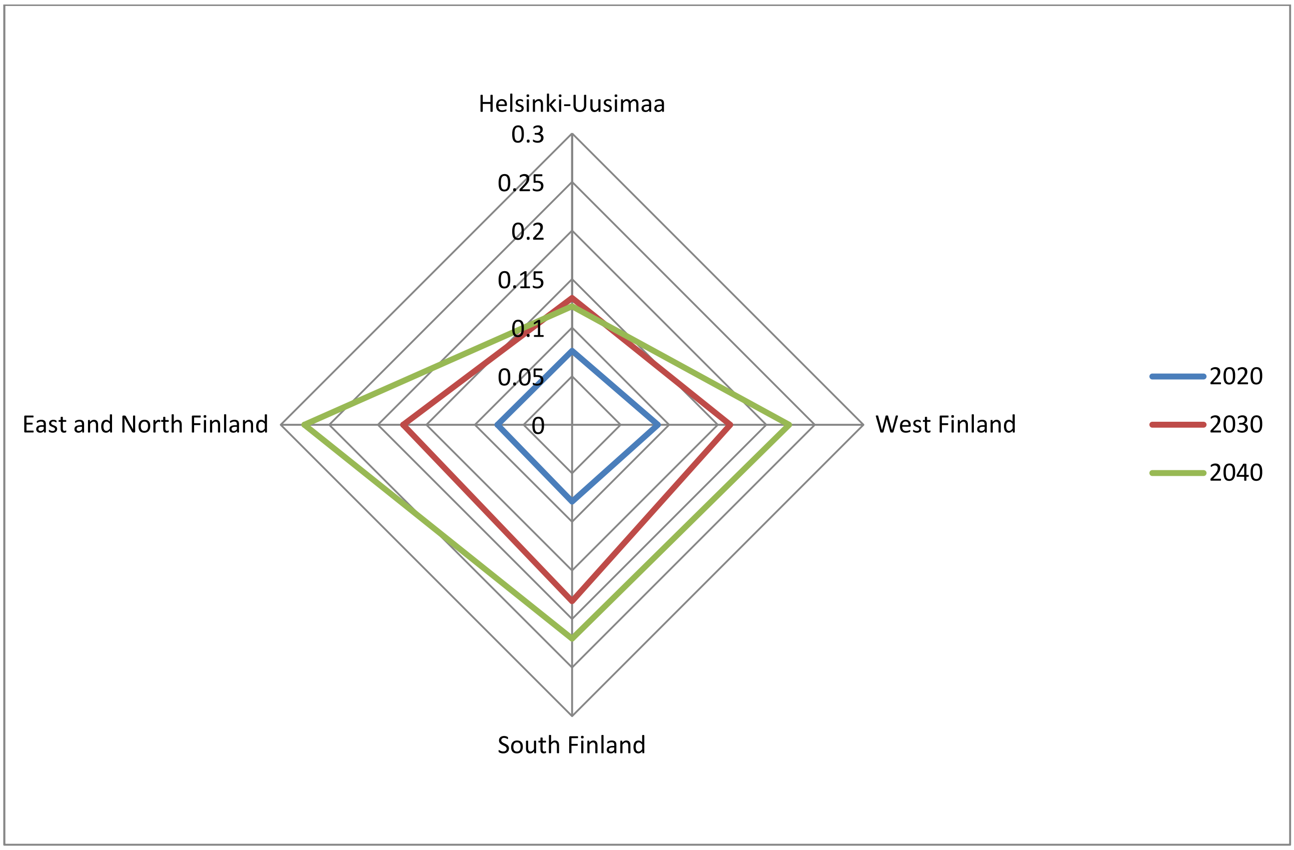

Figure 9. Changes in regional GDP (EED scenario)

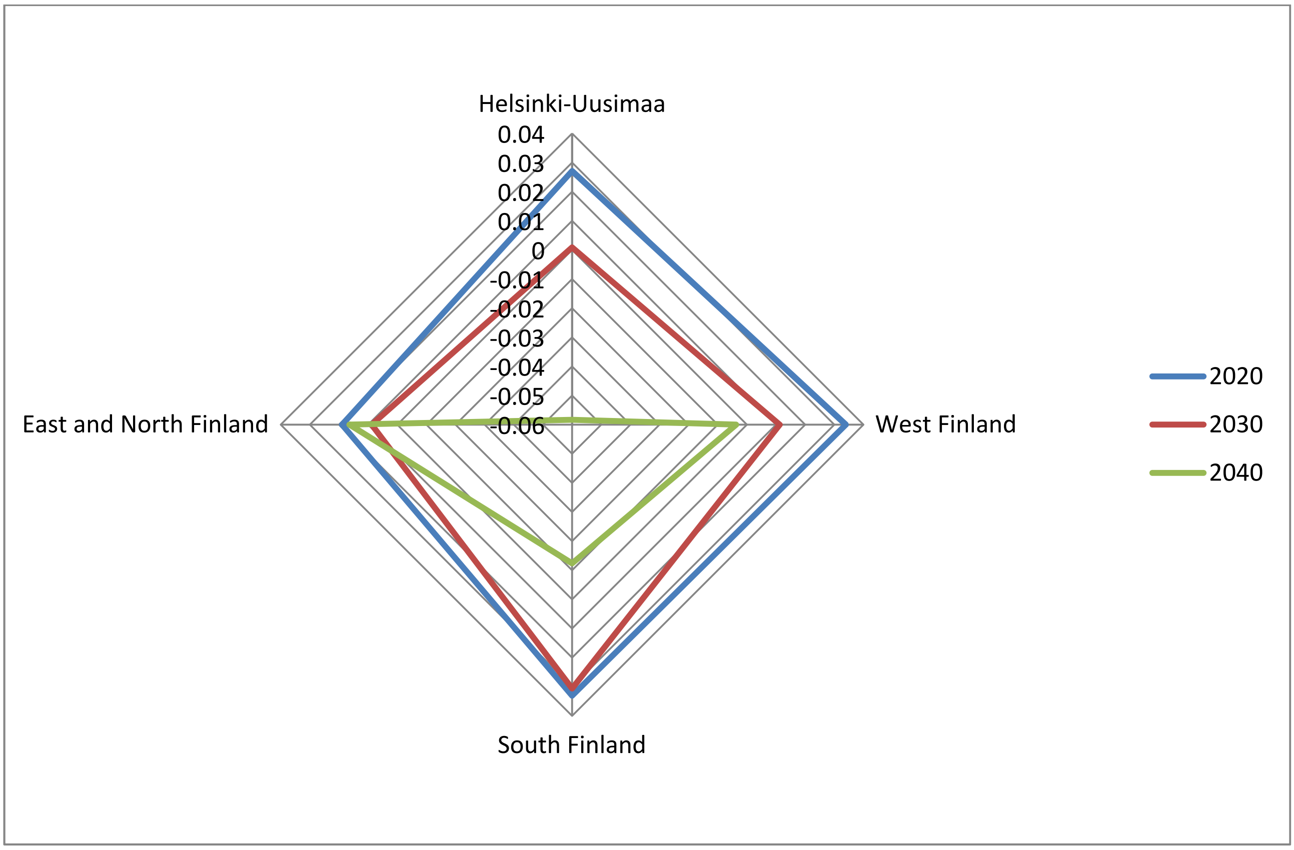

Figure 10. Changes in regional employment (EED scenario)

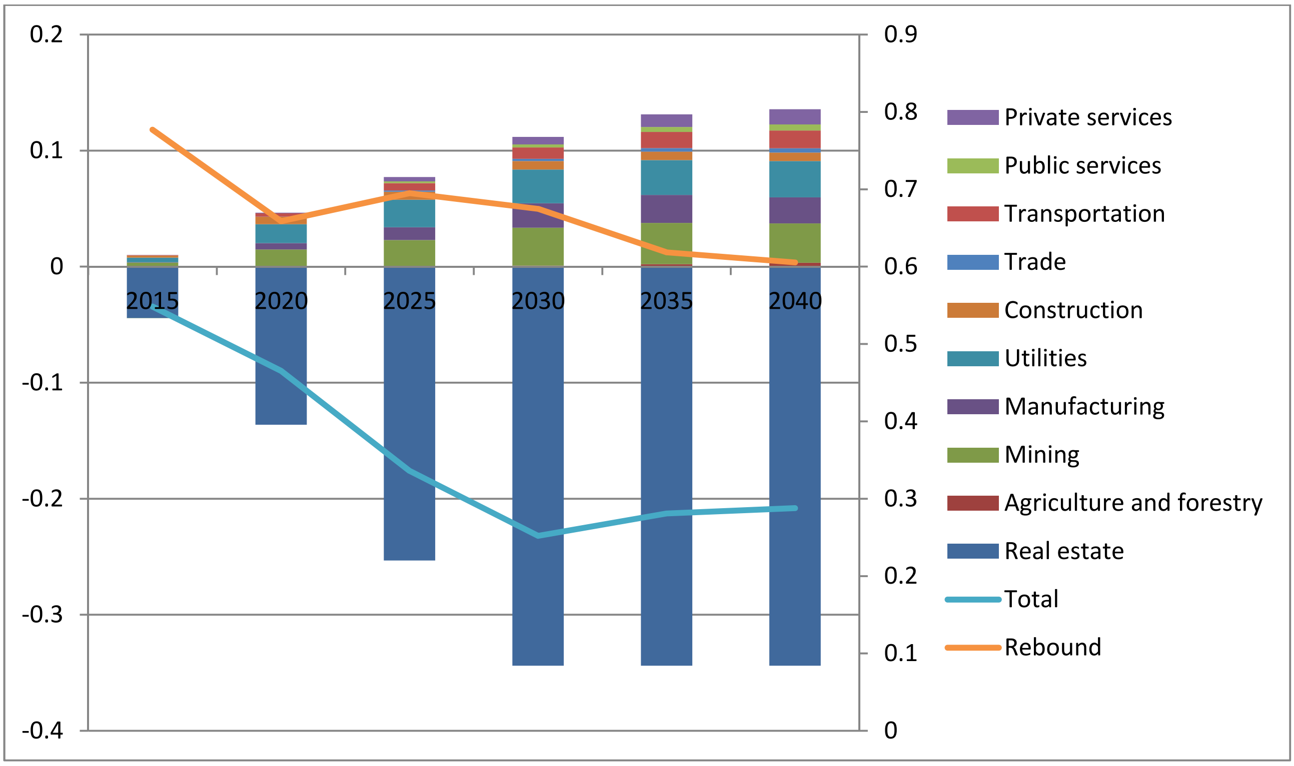

Figure 11. Changes in fuel consumption (EED scenario)

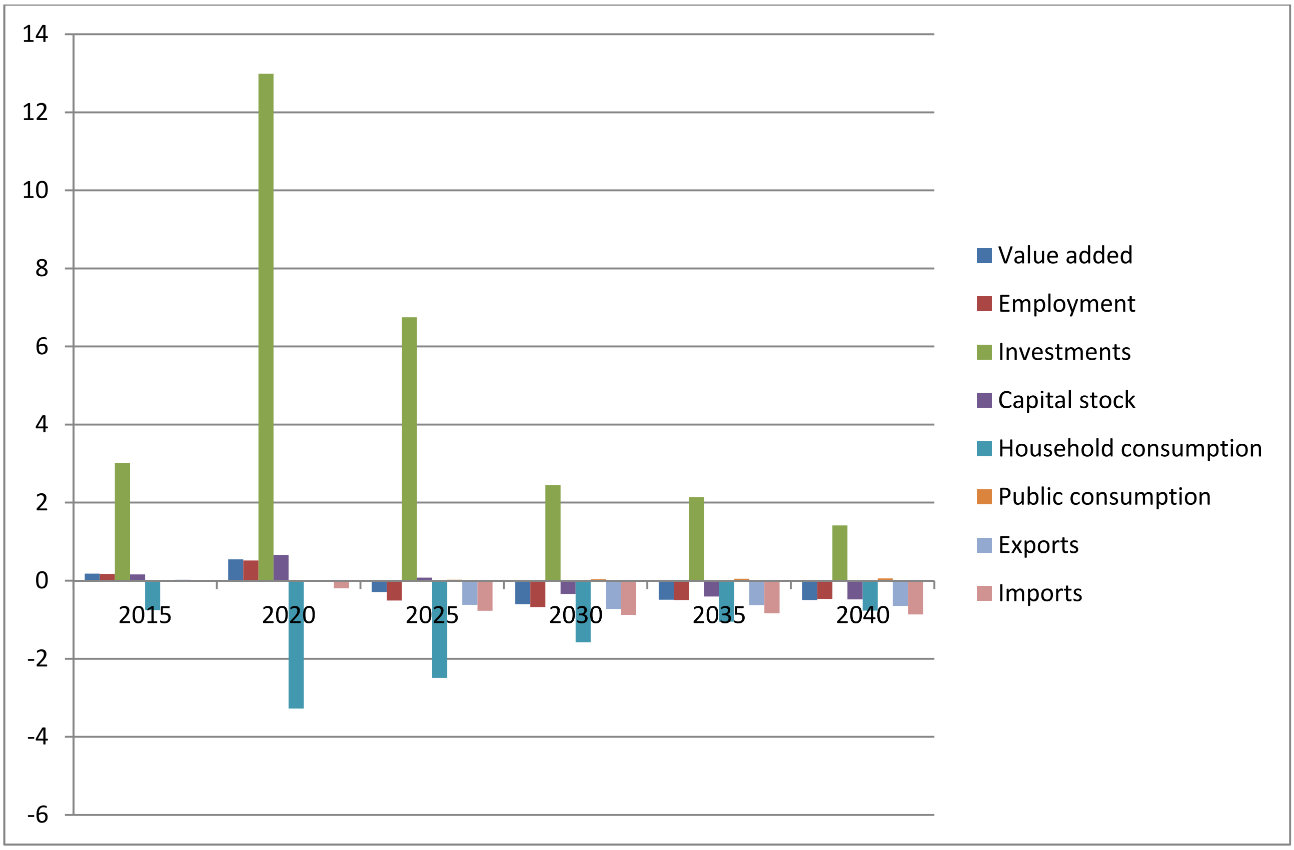

Figure 12. Changes in macro variables (repayment scenario)

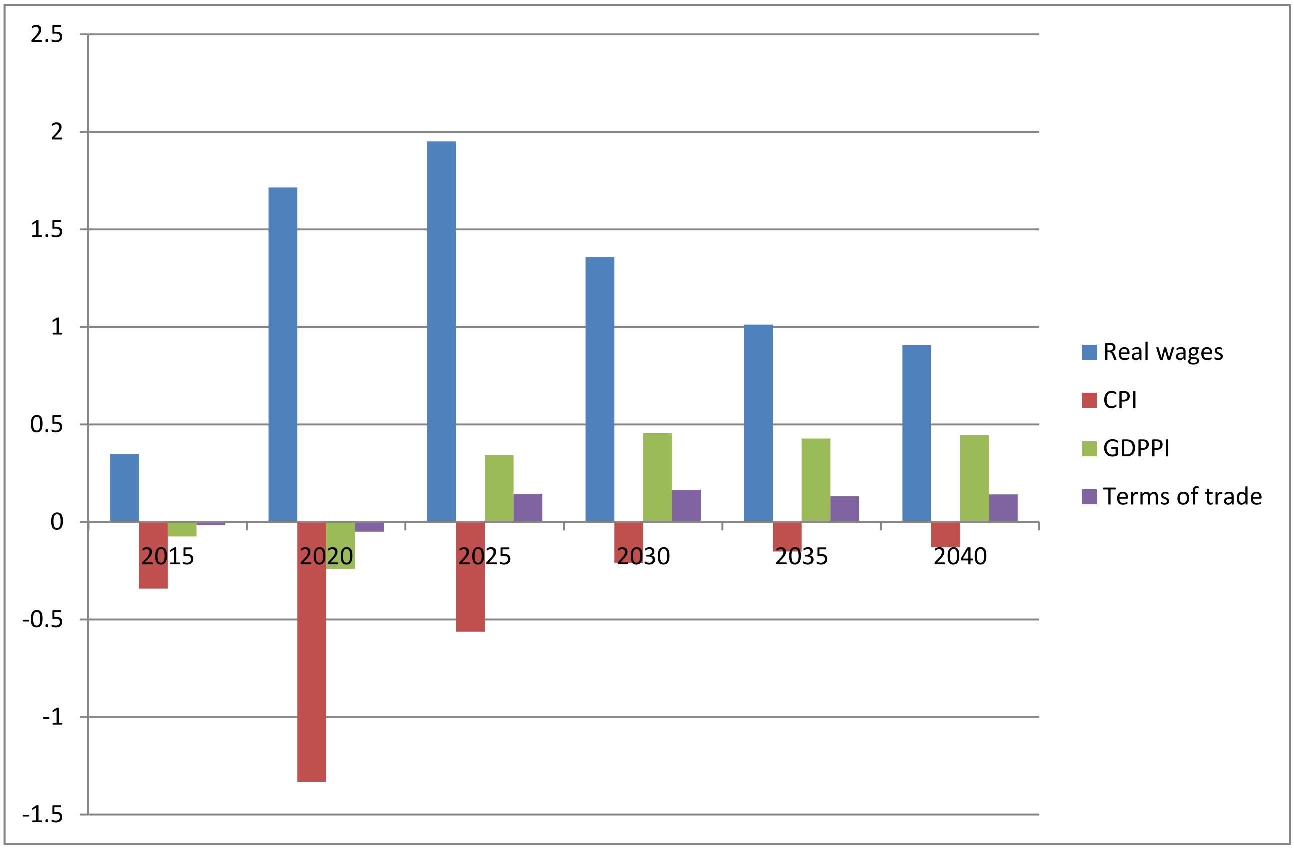

Figure 13. Changes in prices and indices (repayment scenario)

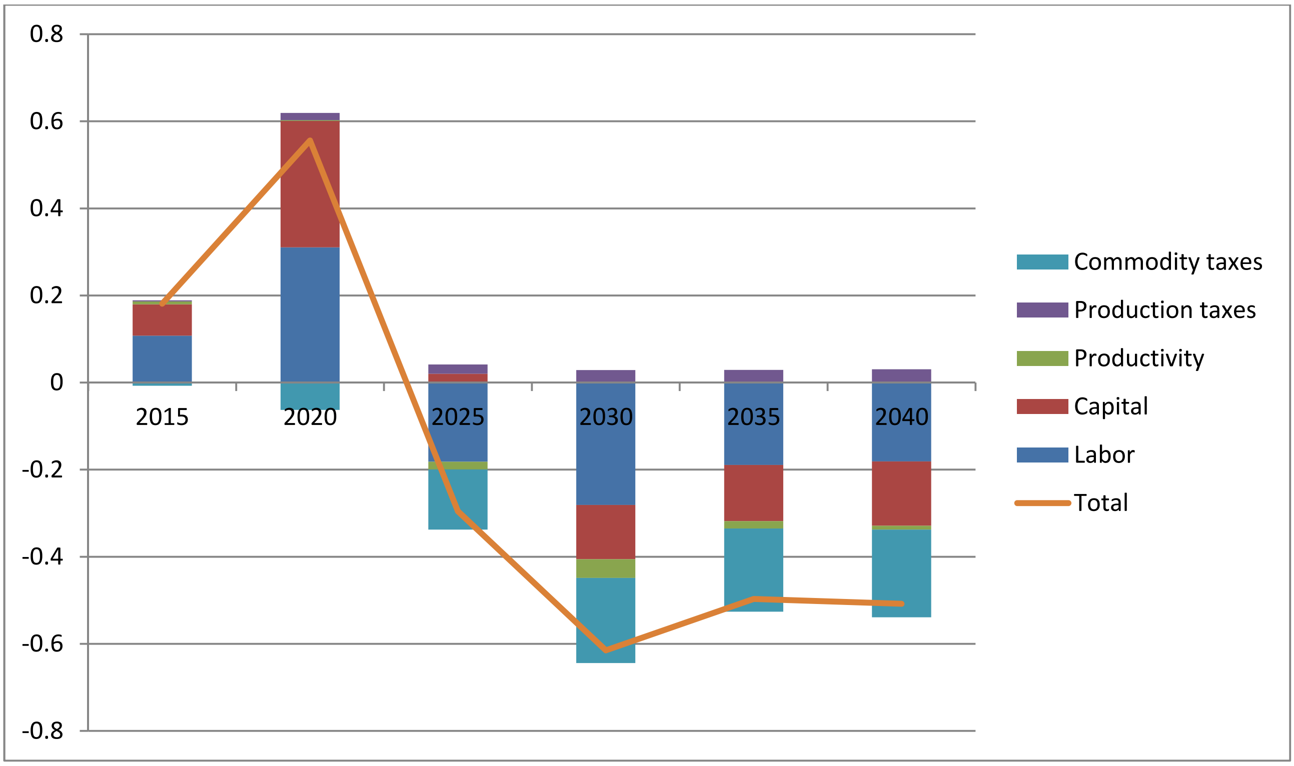

Figure 14. GDP income side decomposition (repayment scenario)

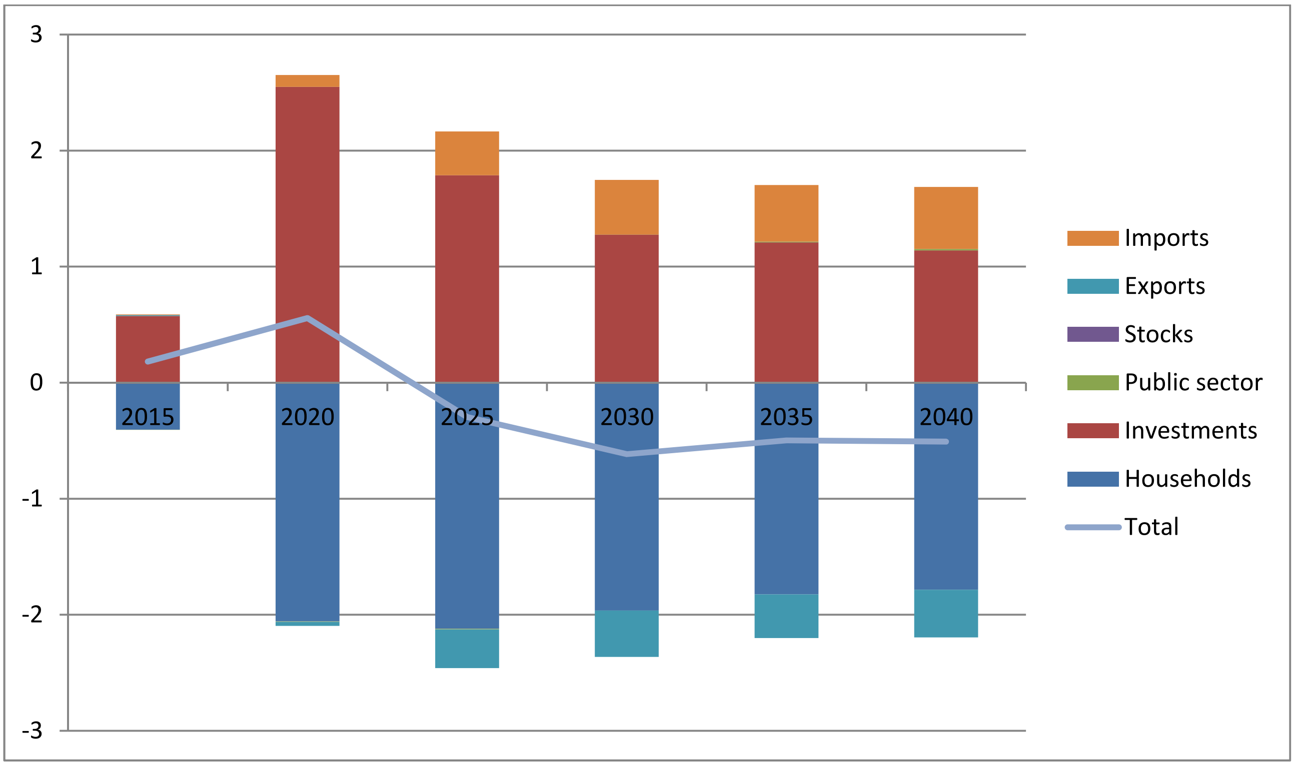

Figure 15. GDP expenditure side decomposition (repayment scenario)

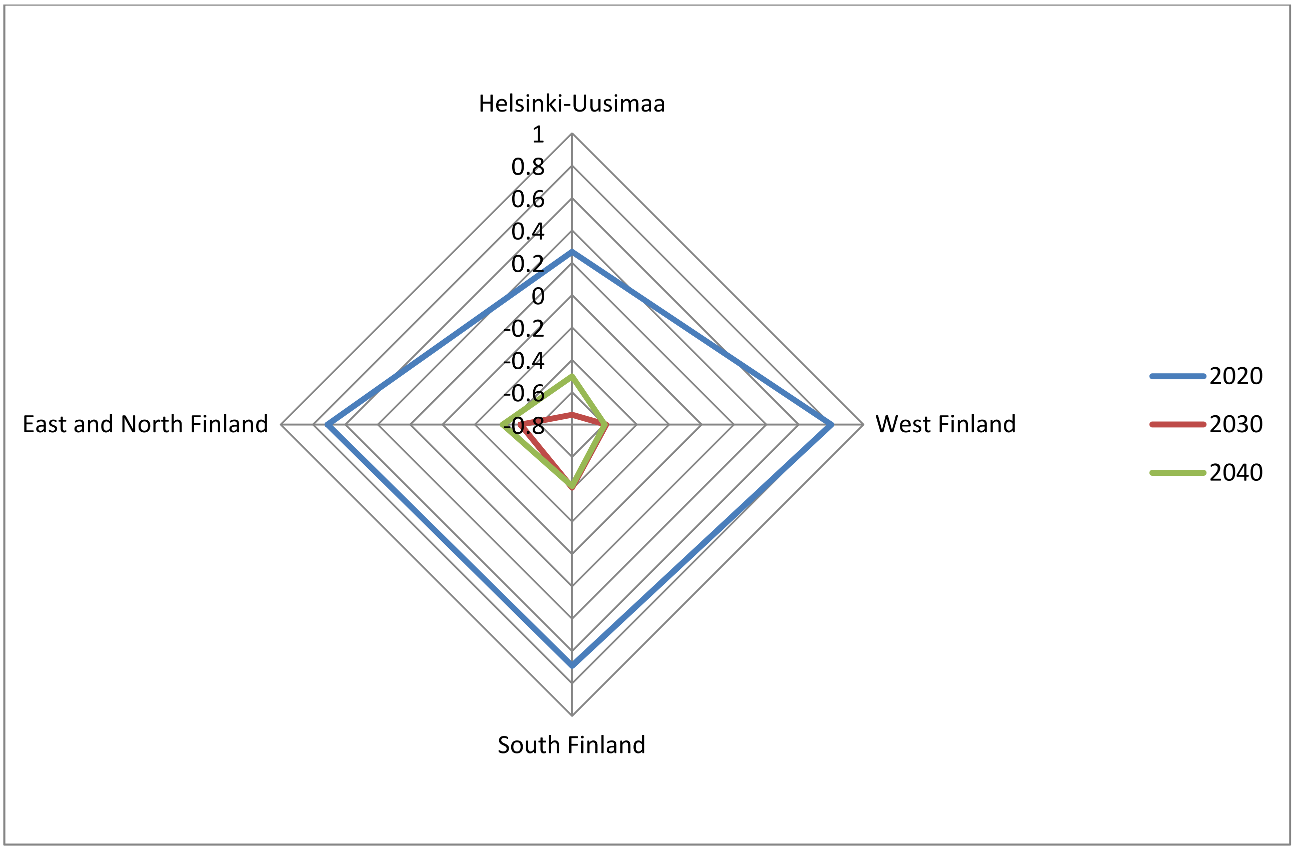

Figure 16. Changes in regional GDP (repayment scenario)

Figure 17. Changes in regional employment (repayment scenario)