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Abstract

This paper studies the effects of structural reforms on the functional distribution of income in EU Member States. To study this mechanism we use a DSGE model (Roeger et al. 2008) with households supplying three types of labour, low-, medium- and high-skilled. We assume that households receive income from labour, tangible capital, intangible capital, financial wealth and transfers and we trace how structural reforms affect these types of incomes. The quantification of structural reforms is based on changes in structural indicators that can significantly close the gap of a country's average income towards the best performing countries in the EU. We find a general trade-off between an increase in employment of a particular group and the income of the average group member relative to income per capita. In general, reforms which aim at increasing employment of low skilled workers are associated with a fall in wages relative to income per capita. Capital owners generally benefit from labour market reforms, with an increasing share in total income, due to limited entry into the final goods production sector. This suggests that labour market re-forms may lead to suboptimal distributional effects if there are rigidities in goods markets present, a finding which confirms the importance of ensuring that such reforms are accompanied or preceded by product market reforms.

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CONTENTS

1. INTRODUCTION

The prolonged slowdown of GDP growth after financial crises has reinforced the need for structural reforms in the European Union. At the same time, income inequality remains at historically high levels in many countries (Keeley 2015, OECD 2011, 2015a, 2016). In particular, high-income households have benefited more than middle and low income ones from the post-crisis recovery. High unemployment and low wage growth has prevented a recovery of labour incomes at the bottom of the income distribution. In fact, real labour income of the bottom 10% has declined in most EU Member States during 2010-2014, i.e. not only in countries in which average real labour income has declined. Furthermore, rising income inequality has not been compensated by a (general) strengthening of redistribution via the tax and transfer system. Recent (related) trends in the distribution of household wealth are summarised, e.g., in Murtin and Mira d'Ercole (2015).

The joint occurrence of slow growth and persistent inequality raises questions about the causes and about potential remedies. Potential drivers of inequality, which include skill-biased technological progress, the effects of globalisation, or the consequences of fiscal consolidation, have received widespread attention in the literature (see, e.g., Card and DiNardo 2002, Agnello and Sousa 2014, Keeley 2015, Lopez Gonzalez et al. 2015). Discussion of remedies beyond standard redistribution by taxes and transfers is patchier. This applies in particular to the role of structural reform and the question of complementarity ("inclusive growth") or incompatibility between the growth and equity objectives.

Traditionally, structural reform proposals have been assessed based on their potential to increase productivity and GDP per capita. Their distributional impact is rarely addressed in the literature (see Causa et al. 2016). This paper contributes to the emerging literature on the distributional impact of structural reforms. It studies the effects of structural reforms on the functional distribution of income in the EU. The analysis uses a DSGE model (Roeger et al. 2008) in which households supply three types of labour, i.e. low-, medium- and high-skilled. We assume that households receive income from labour, tangible capital, intangible capital, financial wealth and transfers, and we trace how structural reforms affect these types of incomes.

In order to use a realistic quantification of structural reforms we rely on Varga and in 't Veld (2014), which applies a distance-to-frontier approach to measure the potential for reforms by assuming a gradual and partial closure of the gap in labour and product market indicators vis-à-vis the average of the three best EU performers. The simulated structural reforms focused on decreasing mark-ups and entry barriers in services and manufacturing, increasing the labour market participation rate for the 55-65 age group, the low-skilled and female workers, raising the share of medium- and high-skilled labour force, tax and unemployment benefit reforms and innovation. Appendix B gives a more detailed description of these structural reform scenarios based on Varga and in 't Veld (2014).

Our findings can be summarised as follows. There is a trade-off between employment and relative incomes. In general, reforms which aim at increasing the employment rate of low skilled workers are associated with a fall of wages relative to income per capita. This effect can be decomposed into wage distribution effects across skill groups but the overall increase in the supply of labour also affects the distribution between wage earners and other income categories, especially capital owners. Capital owners generally benefit from labour market reforms, not only in the form of an absolute increase in capital income but also in the form of an increasing share in total income. This is due to a scale effect in combination with limited entry into the final goods production sector. The relative increase in the capital income share associated with labour market reforms can only be substantially reduced if we allow for entry in the goods market. This suggests that labour market reforms combined with existing goods market rigidities can lead to suboptimal distributional effects. The result echoes the argument in Blanchard and Giavazzi (2003) that labour market reform without product market reform redistributes product market rents from labour to capital without lowering the total size of the rents.

The paper focuses on the effect of structural reforms on (functional) income inequality. It does not discuss the dimension inequality in the distribution of wealth. Inequality in wealth (stock) is at the same time one of the drivers and one of the consequences of the inequality in household income (flow). Wealth generates income to its owner in the form of returns to assets, and higher income facilitates the accumulation of wealth.

Section 2 of the paper provides a sketch of existing research in the field. Section 3 explains the functional definition of income categories in the model as applied in this paper. Section 4 presents and discusses the results for the impact of reforms in product markets, labour markets, the tax and transfer system, and human capital formation on different income categories. Section 5 summarises our findings and concludes.

2. EFFECTS OF STRUCTURAL REFORMS ON THE DISTRIBUTION OF INCOME

With the exception of tax and benefit reforms, the distributional impact of structural reforms has received relatively little attention in the past. A substantial body of research on the widening and persistence of income and wealth inequalities has emerged in more recent years. The efforts of closing the knowledge gap with empirical and theoreticcal work have addressed causes and potential remedies. Notably, the OECD has devoted particular attention to the role of economic policies for inequality.

2.1 EMPIRICAL WORK

OECD studies on the impact of structural policies on inequality have focused on the net real disposable household income across the distribution, i.e. real disposable household income after taxes and benefits. This work (e.g., Causa et al. 2015a, 2015b) finds that many policies deliver higher income gains at the lower end of the income distribution. These policies include measures that strengthen competition in goods markets (reducing regulatory barriers, trade, and FDI), broader access to education, and active labour market policies (ALMP). A general reduction in the generosity of unemployment benefits is also found to raise relative incomes at the lower end of the income distribution, whereas reducing benefits to long-term unemployed lowers household disposable income at the lower end of the distribution.

Other pro-growth policies may have opposite or ambivalent effects on income inequality (OECD 2015b). Examples include the promotion of innovation that widens skill premia across workers. Policies that increase labour force participation particularly in the low-skilled sector may widen the wage dispersion, but have opposite income-enhancing effects through higher employment.

Causa et al. (2016) broaden the analysis by considering the entire income distribution, instead of focusing on the bottom part relative to the average household, and by decomposing the income effect of structural reforms into labour productivity versus labour utilisation effects. OECD cross-country evidence over the last 30 years suggests that most reforms have little impact on income inequality when the latter is defined by measures that emphasise the middle class, whereas a high number of reforms have significant inequality (reducing or emphasising) effects at the lower end of the distribution. Trade-offs between growth and equity are thereby most common for social protection and labour market reforms. Lowering unemployment benefits and social assistance hurts low-income households in particular, which would call for complementary ALMP measures. No rise in income inequality is recorded for moderate reductions in the minimum wage, due to offsetting wage and employment effects for low-income earners. Lower rates of unionisation, to the contrary, are associated with higher income inequality. Lowering labour tax wedges is prone to a growth-equity trade-off in the absence of sufficient progressivity of the tax burden. Causa et al. (2016) also confirms the result from Causa et al.

(2015a, 2015b) of complementarity between growth and equity effects for competition-promoting product market reform and higher government spending on education.

Regarding the tax and benefit system, Cournède et al. (2013a, 2013b) discuss the growth and equity impact of alternative fiscal consolidation strategies. The discussion suggests that lowering (producer) subsidies and increasing corporate and personal income as well as property taxes reduces inequality in disposable income. Higher social security contributions and lower government spending on health, education and social assistance, in contrast, tend to conflict equity objectives in the short and long term.

De Serres and Murtin (2014) take a different perspective by contrasting the long-term (average) impact of labour market policies with the policies' impact on the response of unemployment to adverse shocks.[1] The approach could be reframed as comparing long-term effects on labour income and implications for labour income and income scarcity in recessions. The empirical evidence for 19 OECD countries suggest that less generous unemployment insurance, more ALMP, and lower minimum wages imply a trade-off between long-term employment and short-term income stability. These policies help low-skilled workers getting out of unemployment but make them more vulnerable to adverse shock. Lowering the labour tax wedge avoids the trade-off between the average employment effect and disposable wage income in downturns.

2.2 SIMULATION STUDIES

Model-based studies on the distributional impact of structural reforms are limited in number and have focused particularly on tax and benefit reforms. The literature on tax and benefit reforms distinguishes between micro-simulation studies and general equilibrium analysis. The advantage of micro simulation studies lies in their level of detail concerning the income distribution (see Decoster et al. 2010). However, they tend to ignore how the reforms endogenously affect prices and volumes in the economy leading to second-round effects on income distribution. General equilibrium analyses do not aim to map a detailed household income distribution, but instead focus on coherent modelling of different (functional) sources of income such as income from labour, assets, transfers, benefits etc (see Burgert and Roeger, 2014).[2] Additionally, general equilibrium models can account for price and quantity adjustments in the goods and labour market in response to a reform and their effect on income distribution.

The present simulation study addresses distributional concerns from two angles. First, we focus on how several sources of income (from wages, benefits, transfers, profits and interest payments) are affected by different structural reforms. Tracing the relative development of these income categories allows us to have a disaggregated view on the evolution of households' disposable income. Second, to mimic the income distribution of wage earners, we compare the relative income of low-, medium- and high skilled labour in the model.

Varga and in 't Veld uses the semi-endogenous growth version of the QUEST model specifically adapted for the analysis of structural reforms. The model follows the QUEST3(RD) model structure of Roeger et al. (2008) in a multi-country setting (Varga et al., 2014), and includes the EU Member States individually and the rest of the world as a single separate region. In the next section we show how this aggregate macro model assuming representative households can be used to analyse the effect

[1] The short-term dimension of the comparison relates to the concept of economic resilience to shock. On the latter see, e.g., Duval and Vogel (2008).

[2] General-equilibrium models tend to use sime household and firm structures to remain tractable despite complex interaction and dynamic effects. In particular, these models assume representative households to proxy the average of household behaviour or the behaviour of few distinct (static) household groups (e.g., households in different skill groups or with different financial constraints). The standard assumption of perfect insurance of ideosyncratic risk excludes differentiated income effects at the individual level.

of reforms or other permanent shocks on the distribution of income. We will focus only on those elements of the model which are crucial to understand these distributional effects. The subsequent section presents the income distribution effects of structural reform simulations in detail, and the final section concludes.

3. FUNCTIONAL INCOME DISTRIBUTION

Our model economy is populated by households, final and intermediate goods producing firms, a research industry, a monetary and a fiscal authority. In the final goods sector firms produce differentiated goods which are imperfect substitutes for goods produced abroad. Final good producers use a composite of intermediate goods and three types of labour - low-, medium-, and high-skilled. Non-liquidity constrained households buy the patents of designs produced by the R&D sector and license them to the intermediate goods producing firms. The intermediate sector is composed of monopolistically competitive firms which produce intermediate products from rented capital input using the designs licensed from the household sector. The production of new designs takes place in research labs, employing high skilled labour and making use of the existing stock of domestic and foreign ideas (Jones (1995,2005).. Technological change is modelled as increasing product variety in the tradition of Dixit& Stiglitz (1977). In this section we only discuss those aspects of the model which are relevant for the understanding how structural reforms affect the functional income distribution. Appendix A gives a more comprehensive description of the model and its calibration.

3.1 THE BUDGET CONSTRAINT OF THE REPRESENTATIVE HOUSEHOLD

The household supplies labour (L_t), holds tangible capital (K_t), intangible assets (patents) (A_t), and financial assets (B_t). He receives net wage income from labour at wage rate (W_t^N), rental income form physical capital and intangible assets at rate (i_t^K) and (i_t^A) and interest income from financial assets at rate (i_t). Apart from the rental income on capital, the household also receives monopoly rents from the final goods production sector (PR_t^Y) and the A firms in the intermediate goods sector ($A_t PR_t^x$). Monopoly rents will be treated as part of capital income. Finally, the household receives transfers, which are split into unemployment benefits (BEN_t) and other transfers (TR_t), mostly pensions. The total income received by the household in period t (see RHS of eq. 1) can be used for consumption (C_t) and gross savings (purchases of financial assets ΔB_t, tangible investment J_t^K including depreciation and investment in intangibles ΔA_t adjusted for a tax credit τ^A) (see LHS of eq 1):

$$(1 + t_t^C)C_t + \Delta B_t + P_t^K J_t^K + (1 - \tau^A)P_t^A \Delta A_t = i_{t-1}B_{t-1} + W_t^N L_t + i_{t-1}^K P_t^K K_{t-1} + i_{t-1}^A P_t^A A_{t-1} + PR_t^Y + A_t PR_t^x + BEN_t + TR_t \,, \quad (1)$$

Here we assume that wages paid by the household are after labour taxes and we also assume that the household does not pay interest on rental income, but taxes on capital are paid by the firm. If we want to look at disposable income we also have to deduct depreciation (δ^K, δ^A) and express the budget constraint in terms of net savings and subtract depreciation from the capital income received by the household. This yields the following budget constraint:

$$(1 + t_t^C)C_t + \Delta B_t + P_t^K \Delta K_t + (1 - \tau^A)P_t^A \Delta A_t = i_{t-1}B_{t-1} + W_t^N L_t + (i_{t-1}^K - \delta^K)P_t^K K_{t-1} + (i_{t-1}^A - \delta^A)P_t^A A_{t-1} + PR_t^Y + A_t PR_t^x + BEN_t + TR_t \,. \quad (2)$$

The following accumulation equations for tangible and non-tangible assets are used:

$$J_t^K = \Delta K_t + \delta^K K_{t-1} \quad (3)$$

$$J_t^A = \Delta A_t + \delta^A A_{t-1} \quad (4)$$

Wages:

Net wage income (from final goods production) is the sum of wage income from final production $W_t^{Y,N}L_{Yt}$ and from research $W_t^{A,N}L_{A,t}$:

$$W_t^N L_t = W_t^{Y,N}L_{Yt} + W_t^{A,N}L_{At} \quad (5)$$

Employment in final goods production is divided up into three skill groups, therefore

$$W_t^{Y,N}L_{Yt} = (1 - t_t^{W_L})W_t^L L_{Lt} + (1 - t_t^{W_M})W_t^M L_{M,t} + (1 - t_t^{W_H})W_t^H L_{H,t}, \quad (6)$$

While the research sector only employs high skilled workers

$$W_t^{A,N}L_{A,t} = (1 - t_t^{W_H})W_t^H L_{Ht}^A \quad (7)$$

Note that there are three types of taxes: labour income tax, consumption tax and corporate income tax but this formulation ignores redistribution of income across functional income categories. This is what we turn to next.

Transfers and benefits:

The household receives transfers (TR_t) and unemployment benefits (BEN_t). Benefits are indexed to wages, and transfers are indexed to the consumer price deflator:

$$BEN_t = \sum_{s\in\{L,M,H\}} bW_{s,t}(1 - NPART_{s,t} - L_{s,t}) \quad (8)$$

$$TR_t = TR_0 P_t^C \quad (9)$$

where $1\text{-}NPART_{s,t} - L_{s,t}$ is the number of unemployed per skill group, $NPART_{s,t}$ is the number of inactives, and b is the benefit replacement rate.

Capital income:

The household receives interest income from the holding of government bonds and from net foreign assets:

$$INC(financial\ wealth) = i_{t-1}B_t \quad (10)$$

as well as rental income from tangible and intangible capital:

$$INC(net\ rental, tangible\ capital) = (i_{t-1}^K - \delta^K)P_t^K K_{t-1} \quad (11)$$

$$INC(rental, intangible\ capital) = (i_{t-1}^A - \delta^A)P_t^A A_{t-1} + \tau^A P_t^A \Delta A_t \quad (12)$$

Arbitrage in financial markets implies that rates of return are equalised across different assets (up to a risk premium [3]). Therefore the rental rate on physical capital and the rental rate on intangible assets is related to the nominal interest rate on financial assets as follows

[3] We assume that reforms do not affect risk premia.

- Tangible capital:

$$i_t^K = r_t + \pi_{t+1}^Y - \pi_{t+1}^K + \delta^K + rp^K = i_t - \pi_{t+1}^K + \delta^K + rp^K \quad (13)$$

- Non-tangible capital:

$$i_t^A = (1-\tau^A)(r_t + \pi_{t+1}^Y - \pi_{t+1}^A + \delta^A) + rp^A = (1-\tau^A)(i_t - \pi_{t+1}^A + \delta^A) + rp^A. \quad (14)$$

The (nominal) return on tangible capital exceeds the (nominal) return on financial assets by the rate of depreciation (and the risk premium). In case of expected capital gains arbitrage reduces i_t^K. Similarly the rate of return on intangible assets differs from the risk free rate by an expected capital gain, a tax credit τ^A on intangible investment (and a risk premium). Another source of capital income are pure profits or monopoly rents of final goods producers (PR_t^Y) and intermediate goods producers (PR_t^x), since both types of firms act under monopolistic competition. As explained in the next section, both types of firms are facing fixed costs and entry costs. Whether monopoly rents will be positive depends therefore on entry conditions into the market for final and intermediate goods.

3.2 PROFITS

Intermediate production

There are A (as many as there are patents for producing intermediate goods) intermediate goods producers. Intermediate goods producers rent tangible and intangible capital. The technology is constant returns in tangible capital, while intangible capital is a fixed cost for the firm. The production technology is given by

$$x_t^i = K_t^i \quad (16)$$

The profit of intermediate producer i ($PR_{t,i}^x$) is the difference between revenues and the rental price of physical capital i_t^K and intangible capital i_t^A and the interest payments for financing a fixed administrative entry cost FC_A

$$PR_t^{x^i} = P_t^{x^i} x_t^i - i_t^K P_t^K K_t^i - i_t^A P_t^A - r_t FC_A \quad (17)$$

Intermediate goods producers charge a mark up over marginal cost which is a function of the elasticity of substitution between alternative intermediate inputs in final production. The rental cost for physical capital can be seen as variable cost for the firm, since these costs are proportional to the level of output, Consequently, marginal cost for intermediate firm i is given by

$$MC_t^i = i_t^K P_t^K \quad (19)$$

And the intermediate good price is set as a mark up mup_t^x over marginal cost

$$P_t^{x^i} = (1 + mup_t^x) i_t^K P_t^K \quad (20)$$

The rental cost for the patent and the administrative entry cost are fixed costs, they must be paid irrespective of the level of output. There is free entry into the market for intermediate goods. The free entry condition determines the number of intermediate goods firms A such that $PR_{t,i}^x = 0$. Entry reduces revenues of intermediate goods firms up to the point where the mark up is covering the fixed costs for the intermediate goods producer.

Final goods producers

The final goods producers (*j=1,….,n*) are buying capital services as intermediate input for production and hires labour. Final output is produced using labour $L_{Y,t}$, intermediate capital inputs $x_{m,t}$ and public capital. Production is subject to general per period fixed cost FC_Y.

$$Y_{jt} = \left(L_{Yjt}\right)^{\alpha} \left(\int^{A_t} \left(x^i{}_{jt}\right)^{\theta} di\right)^{(1-\alpha)/\theta} KG_t^{\alpha_G} - FC_Y \tag{25}$$

Labour is a CES aggregate of different skill types with

$$L_{Yjt} = \left(\Lambda_L^{1/\mu} \left(\chi_L L_{Ljt}\right)^{(1-\mu)/\mu} + \Lambda_M^{1/\mu} \left(\chi_M \left(L_{Mjt} - FC_L\right)\right)^{(1-\mu)/\mu} + \Lambda_{HY}^{1/\mu} \left(\chi_{HY} L_{HYjt}\right)^{(1-\mu)/\mu}\right)^{\mu/(1-\mu)}, \tag{26}$$

where $L_{L,t}$, $L_{M,t}$ and $L_{HY,t}$ denote the employment of low, medium and high-skilled in final goods production. A fixed number of workers with medium skills are employed as overhead labour FC_L . Parameter Λ_z is the corresponding share parameter $\left(z \in \{L, M, HY\}\right)$, χ_z is the efficiency unit, and μ is the elasticity of substitution between different labour types.

The final goods producer *j* is monopolistic competitor. The firm maximises net profits PR_t^Y with a tax rate on profits equal to t_t^P.

$$PR_{jt}^Y = (1 - t_t^P)(P_{jt}^Y Y_{jt} - (1 + ssc_t) W_t\, L_{jt}) - A_t x_{jt} P_t^x. \tag{27}$$

The FOCs w. r. t. labour and intermediate inputs is given by

$$(1 - t_t^P)\left(1 - mup_{jt}^Y\right)\alpha \frac{\left(Y_{jt} + FC_Y\right)}{L_Y} = (1 + ssc)\frac{W_t}{P_t^Y} \tag{28}$$

$$(1 - t_t^P)\left(1 - mup_{jt}^Y\right)(1 - \alpha) \frac{\left(Y_{jt} + FC_Y\right)}{Ax_{ji}} = \frac{P_t^x}{P_t^Y} \tag{29}$$

where mup_t^Y is the price mark up. From the FOCs it follows that profits of the final goods producing sector can also be expressed as a positive function of monopoly rents and depend negatively on fixed costs

$$PR_{jt}^Y = mup_{jt}^Y P_{jt}^Y Y_{jt} - \left(1 - mup_{jt}^Y\right) P_{jt}^Y FC_Y - W_t FC_L \geq 0 \tag{30}$$

In the case of final goods firms we allow positive profits. In the simulations we present below, however, we distinguish between a constant mark up case and an entry deterrence case. As can be seen from the profit equation, because of fixed costs any increase in output generated by structural reforms will generally increase profits permanently if mark ups remain constant. This may, however, be an unrealistic assumption, since in the long run one would expect entry of new firms or a response of incumbent firms to deter entry. In the simulations presented below we show results with constant mark ups but we also show results with entry deterrence, i. e. incumbent firm reduce mark ups such as to stabilise profits at their baseline level. Comparing both cases is particularly interesting in the case of labour market reforms. The constant mark up case represents a scenario with labour market reforms under rigid goods markets while the second case represents a scenario of labour market reforms under flexible goods markets. The alternative case with entry of new firms could also be modelled by increasing fixed costs in order to satabilise profits.

3.3 CALIBRATION

The calibration of model parameters is explained in more detail in the appendix to this paper. Here we only discuss those aspects of the calibration which are crucial for this exercise. We estimate sectoral mark ups using EU KLEMS data. Aggregating mark ups across sectors suggests an aggregate final goods mark up in the range between 10 and 30% across EU countries (all Member States). We determine fixed costs such that the model can reconcile relatively large mark ups with modest profit rates. We choose steady state rental rates such that the model can generate a capital output ratio of 3 and an R&D share of 0.5-3%. The mark-up estimates, together with the output elasticity of labour, are set such that the model can replicate the wage share across EA Member States.

Since many labour market reforms are affecting the skill composition of employment, special emphasis must be given to the skill parameters in production and labour supply by skill. The consensus estimate of the elasticity of substitution between skilled and unskilled labour is between 1.0 and 2.0 (Katz and Autor, 1999). Acemoglu and Autor (2011) recently updated the seminal reference of this elasticity parameter by Katz and Murphy (1992, "KM" hereafter). While KM estimated that the elasticity of substitution between skilled and unskilled labour is about 1.4, Acemoglu and Autor (2011) argues for somewhat higher estimates in the range of 1.6-1.8 using an extended data sample of KM (from 1963 to 2008 as opposed to 1968-1987). In the simulation exercise we used the middle value of this range $\mu=1.7$. Note that an elasticity of $\mu<1$ could result in a simultaneous decline of high-skilled real wages and relative wage shares after an increase in their population share (See Graphs 3.6.1.b.). Concerning labour supply we calibrate the elasticity parameters such that the model can replicate skill specific unemployment rates.

4. THE IMPACT OF REFORMS ON INCOME CATEGORIES

In this section we will discuss, for each of the reform measures considered here, the effects on the functional income distribution. In order to use a realistic quantification of structural reforms, we base the magnitude of each reform shock on a benchmarking exercise, which applies a distance-to-frontier approach to measure the potential for reforms by assuming a gradual and partial closure of the gap in labour and product market indicators vis-à-vis the average of the three best EU performers. The results for all EU member states are then aggregated to show the impact on the EU aggregate. [4]The simulated structural reform scenarios first focus on labour market reforms that increase the labour market participation rate for low-skilled, older, and female workers, respectively, unemployment benefits reforms, as well as human capital investment raising the share of the medium- and the high-skilled labour force. Next we consider product market reforms that decrease mark-ups and entry barriers in services and manufacturing, and tax reforms and innovation subsidies. For each reform scenario, graphs show the change in income shares after 5, 10, 20 and 50 years, and developments in wages and wage sums in the first 10 years and in the long term (Appendix B gives a more detailed description of these structural reform scenarios based on Varga and in 't Veld (2014). The discussion in the text below is limited to the results in qualitative terms, i.e. without particular reference to the magnitude of effects (which are, however, visible in the Graphs).

The structure of the economy, notably the production function, has implications for how structural reforms affect different income components, such as wage income, returns to capital, and firm profits. The reforms that we consider in this section have positive GDP growth effects, and most of them also lead to increasing employment. Pro-competitive product market reform, e.g., is generally associated with employment and real wage growth. In the case of labour market reforms, the response of wages is

[4] As these scenarios simulate reforms in all member states at the same time, the results also include cross-border spillover effects, but these are generally limited for structural reforms (see the discussion in Varga and in 't Veld , 2014).

more context-specific, however, so that the wage share as the product of wages and employment relative to GDP can in theory either rise or fall.

4.1 LABOUR MARKET PARTICIPATION REFORMS

As mentioned above, the wage and wage sum effects of labour market reforms depend on structure of production and the labour market as well as on the specificities of the reform scenario. Our analysis builds on a model that uses a production function where firms use capital services and labour, and where labour is an aggregate of low-skilled, medium-skilled and high-skilled workers (see equations 25-26 in section 3.2). What should we expect in terms of wage income and wage shares from labour market reforms that increase (i) overall labour supply, or (ii) the participation of different types of workers, where the latter is associated with a (permanent) change in the skill composition of the labour force?

A standard macroeconomic model with constant returns to scale provides the following answer (see Appendix C for more detailed and formal discussion): General labour market reforms generate a trade-off between higher employment and lower wages in the short run, due to frictions (such as price stickiness and employment adjustment costs) that dampen the increase in labour demand initially. There is no trade-off in the long run, however. Labour market reform which increases employment also leads to an increase in the capital stock in the long term until the initial capital-output ratio, which is determined by the long-term real interest rate net of capital depreciation, is re-established. With an unchanged post-reform capital-labour ratio, the post-reform marginal product of labour is also unchanged, which supports an unchanged real wage.

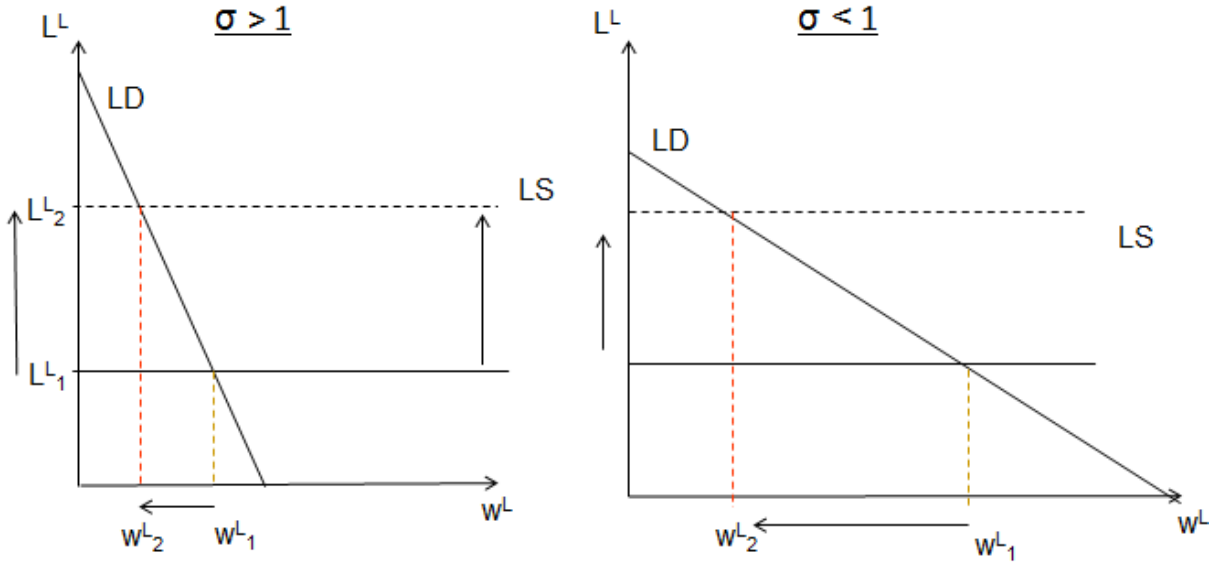
In the case of skill-specific labour market reforms, aggregate employment and wages still behave as for general reforms, i.e. a trade-off between higher employment and lower wages in the short term, and higher employment with a return of real wages to pre-reform levels in the longer term. The (relative) wages for individual skill groups will change, however, also in the long run.

If, e.g., low-skilled labour supply increases relative to the total labour force for a given production technology, low-skilled (relative) wages will have to fall to absorb the additional low-skilled workers. The fall in the skill-specific wage is due to a loss in skill-specific labour efficiency that is associated with an increase in (relative) labour supply in the particular skill group. The efficiency loss finds its expression in the decreasing marginal product of the particular skill type.

The strength of permanent wage effects in response to skill-specific labour supply shocks depends on the substitutability between different skills in production. The lower the elasticity of substitution between skill types, the stronger the trade-off in terms of negative wage effects becomes. If different skills are (nearly) perfect substitutes the trade-off disappears.

The impact of a skill-specific labour supply expansion on skill-specific labour income, i.e. wage times employment, is illustrated in Graph 1, which shows the long-run effect of an expansion in the low-skilled work force for a given demand curve for low-skilled workers. The horizontal labour supply schedule describes the case in which (relative) wages adjust fully, so that the expanded labour force is fully employed.

Graph 1. **Wage and wage sum effects of an increase in low-skilled labour supply**



The left panel of Graph 1 depicts the case, where the elasticity of substitution in labour demand between skill groups is above unity ($\sigma>1$). The low-skilled labour supply (LS) moves up from L_1 to L_2. The low-skilled wage level falls from w_1 to w_2. For the skill-specific labour demand elasticity above unity, the per-cent increase in low-skilled employment is larger than the per-cent decline in the wage, so that wage share of low-skilled workers increases ($w^L_2L^L_2>w^L_1L^L_1$).

The right panel of Graph 1 illustrates the situation, where the elasticity of substitution in labour demand between skill groups is below unity ($\sigma<1$). The low-skilled labour supply (LS) moves up from L^L_1 to L^L_2 as before, but it is now confronted with a flatter labour demand schedule LD(w^L), leading to a more pronounced wage decline from w^L_1 to w^L_2. For the skill-specific labour demand elasticity below unity, the per-cent increase in low-skilled employment is smaller than the per-cent decline in the wage, so that wage share of low-skilled workers declines ($w^L_2L^L_2<w^L_1L^L_1$).

As described in Section 3.3 above, the consensus estimate in the empirical literature for the elasticity of substitution between skilled and unskilled labour is between 1.0 and 2.0, and it is set to 1.7 in the calibration of our benchmark model. These values imply an increase in the income share of low-skilled labour in response to expansing low-skilled labour supply as in the left panel of Graph 1.

The impact on net disposable income of wage earners will also depend on the interaction of structural reforms with, notably, fiscal policy. Depending on the indexation of benefits and transfers to wages, the level of benefits and transfers may decline with falling wages. In our model, benefits are indexed to wages, whereas transfers are indexed only to purchasing power, i.e. to the consumer price index. To the extent that labour demand adjusts only sluggishly to labour force growth, the number of benefit receipients increases, however.

Structural reforms are likely to improve the budgetary position of the government by increasing direct and indirect tax revenue, and by a favourable denominator effects with regard to debt and deficit levels relative to GDP. In our reform scenarios, budgetary gains are rebated to households in form of a labour tax reduction in the medium and longer term, which will permanently improve net disposable income for given gross labour revenue.

4.1.1 Low-skilled participation

The first reform considered here is an increase in the (male) low-skilled labour force participation rate by around 4.2 percentage points (pp) at the EU aggregate level, i.e. a skill-specific labour supply expansion as discussed at the beginning of section 4. The results for wages and income shares are dis-

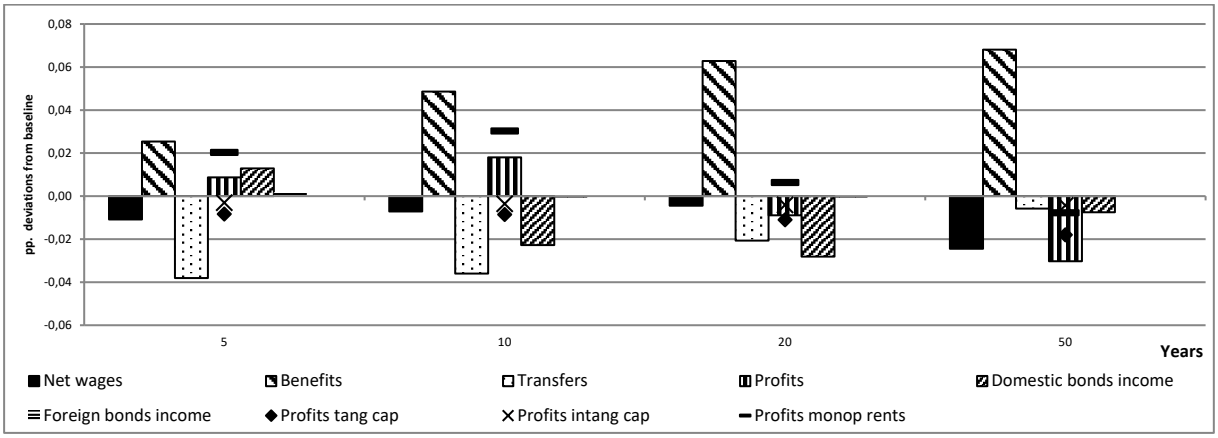
played in Graph 2. There is a clear trade-off between higher employment and lower relative wages in the low-skilled segment. Low-skilled labour supply increases while the labour demand schedule remains unchanged. The hourly (real) wage of low-skilled workers falls as a result (panels 2.4) as well as the share of low-skilled wages in per-capita income (panel 2.5). The total wage sum for low-skilled labour, i.e. the product of wages and hours worked in the segment, increases (panels 2.2 and 2.3), as explained above, given that the labour demand elasticity in our model is larger than one (left panel of Graph 1) in line with the empirical evidence.

The low-skilled labour force participation increase affects the relative contribution of different income sources to net disposable household income (panel 2.1). The income share of transfers to households declines with higher income, because transfer volumes are kept constant in absolute terms in the scenario. Expenditure on social security benefits, to the contrary, rises. The income share of profit income increases temporarily, as falling wages in response to increasing labour supply lead to higher monopoly rents, whereas lower returns on tangible and intangible capital dampen profit income in the longer term. Lower returns on domestic bonds are a consequence of lower nominal interest rates associated with an accommodative monetary policy response to positive supply shocks, and of a reduction in the level of government debt.

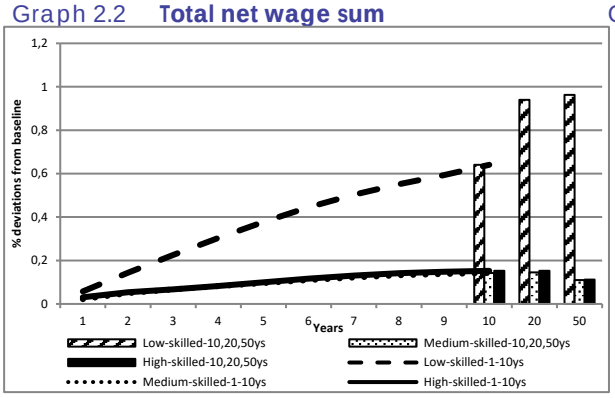
The increase in low-skilled labour force participation, without changes to the medium-skilled and high-skilled labour force, has little impact on the wage income of medium- and high-skilled workers. The net consumption wages of medium- and high-skilled workers increase gradually and slightly in real terms (panel 2.4), which is the consequence of lower relative wages for low-skilled workers, an associated decline in production costs and prices, and a reduction in the labour income tax. The net wage increase also leads to an increase in the real wage sum for the medium and highly skilled (panel 2.2). The share of medium- and high-skilled labour income in total and per-capita net disposable income, to the contrary, declines slightly, which reflects the increased wage share of the low-skilled sector and the relative increase in benefit income.

Graph 2. **Increase in low-skilled labour force participation**

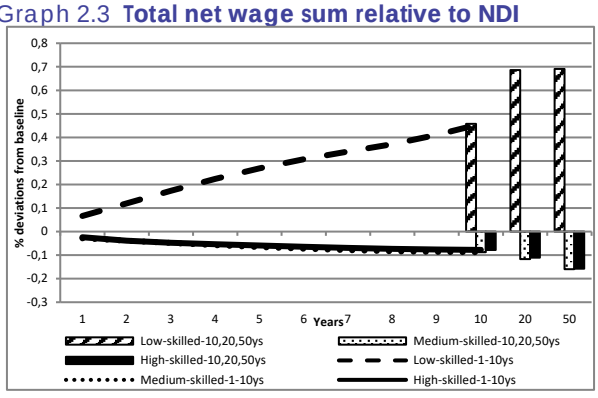
Graph 2.1 **Change in income shares (% of NDI)**



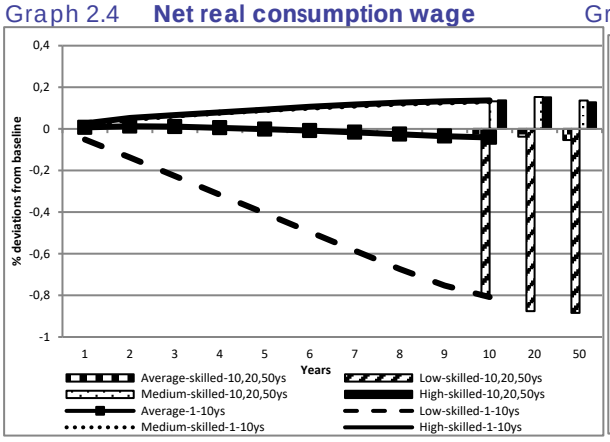
Graph 2.2 **Total net wage sum**



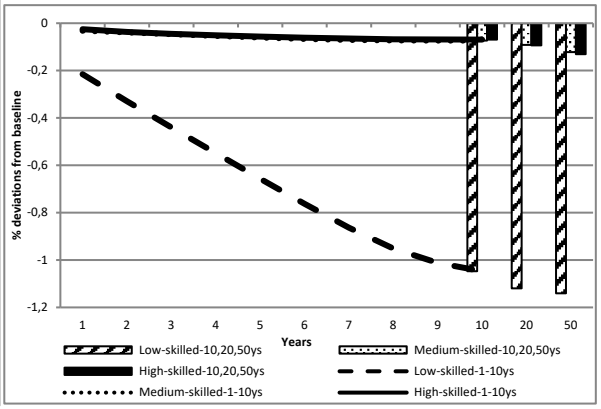
Graph 2.3 **Total net wage sum relative to NDI**



Graph 2.4 **Net real consumption wage**



Graph 2.5 **Net wage relative to per-capita NDI**



Note: The first graph shows the change of income shares in pp. deviation, the second and third graphs show the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

Source: Commission services

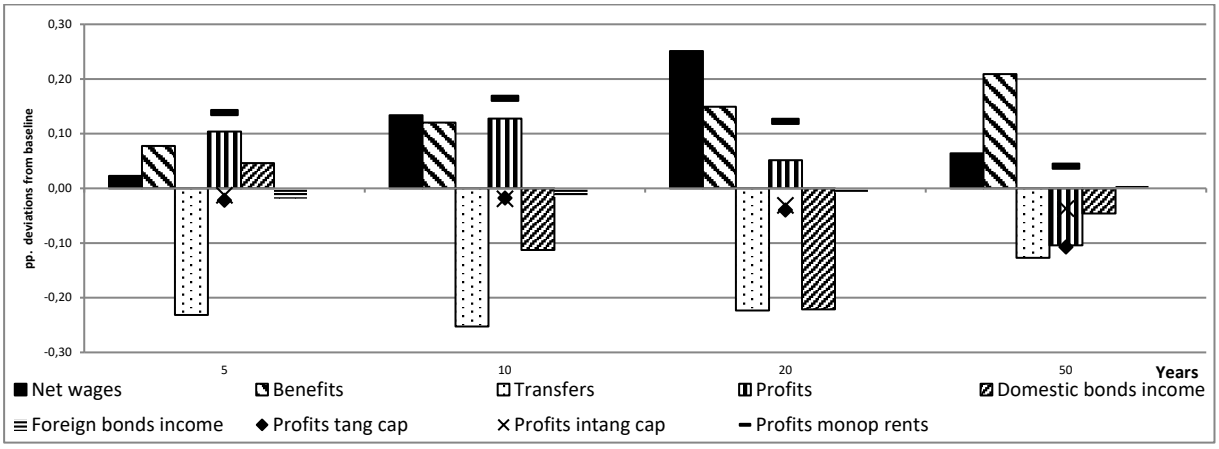
4.1.2 Female participation

The second labour market reform scenario considered here consists of an increase in labour supply across all skill categories (contrary to only low-skilled participation in 4.1.1). The quantification of the reform follows the approach of closing the gap with best performance in terms of female participation per skill group, which overall amounts to 4.5 pp increase in the female participation rate. The reform is simulated as an exogenous shock for simplicity. Policy measures to achieve an increase in female participation rates could, e.g., include increasing the supply of child care facilities.

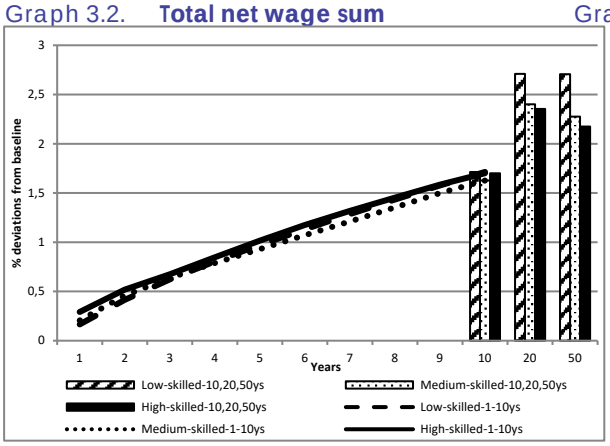
Empirically, participation gaps in the EU are largest for lower-qualified labour. By implication, the closing-the-gap scenario (still) has a bias toward participation growth notably in the low-skilled group. The scenario, in other words, is not a uniform increase in labour force participation across all skill levels, but an overall increase that is most pronounced in the low-skilled segment.

Graph 3. **Increase in female participation - without entry**

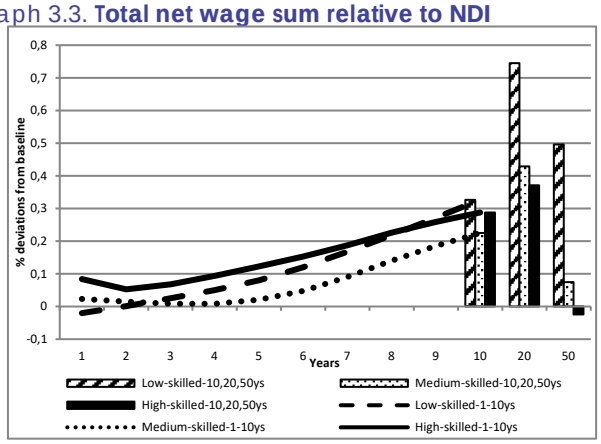
Graph 3.1. **Change in income shares (% of NDI)**



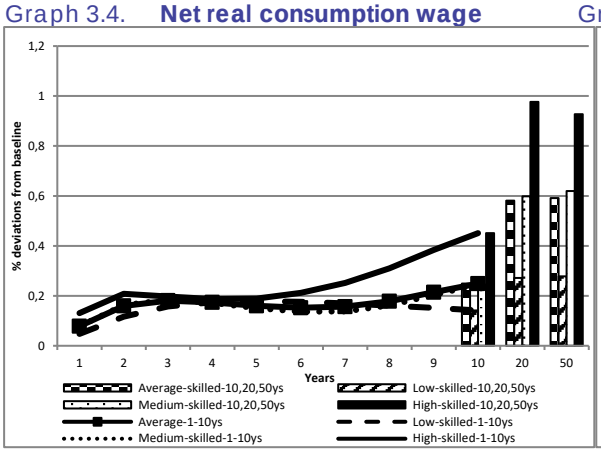
Graph 3.2. **Total net wage sum**



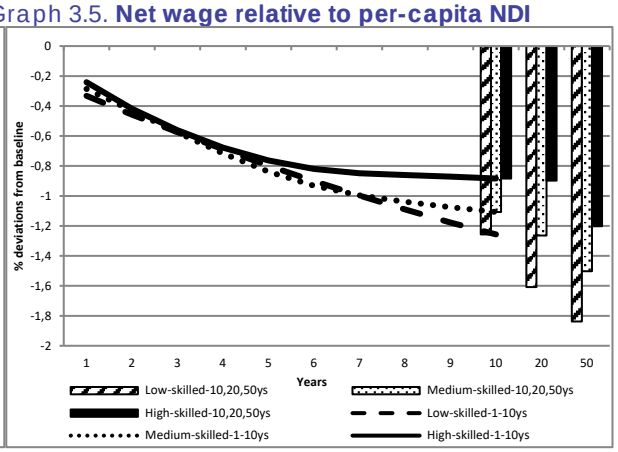
Graph 3.3. **Total net wage sum relative to NDI**



Graph 3.4. **Net real consumption wage**



Graph 3.5. **Net wage relative to per-capita NDI**



Note: The first graph shows the change of income shares in pp. deviation after 5, 10, 20 and 50 years,, the second and third graphs show the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

Source: Commission services

The results for the simulated scenario are summarised in Graph 3. The wage sum, which is the product of wages and employment, increases across the three skill groups (panel 3.2), driven by the increase in employment. Gross real wages decline, on average, but net real consumption wages increase due to a reduction in the labour income tax that rebates the budgetary surplus.

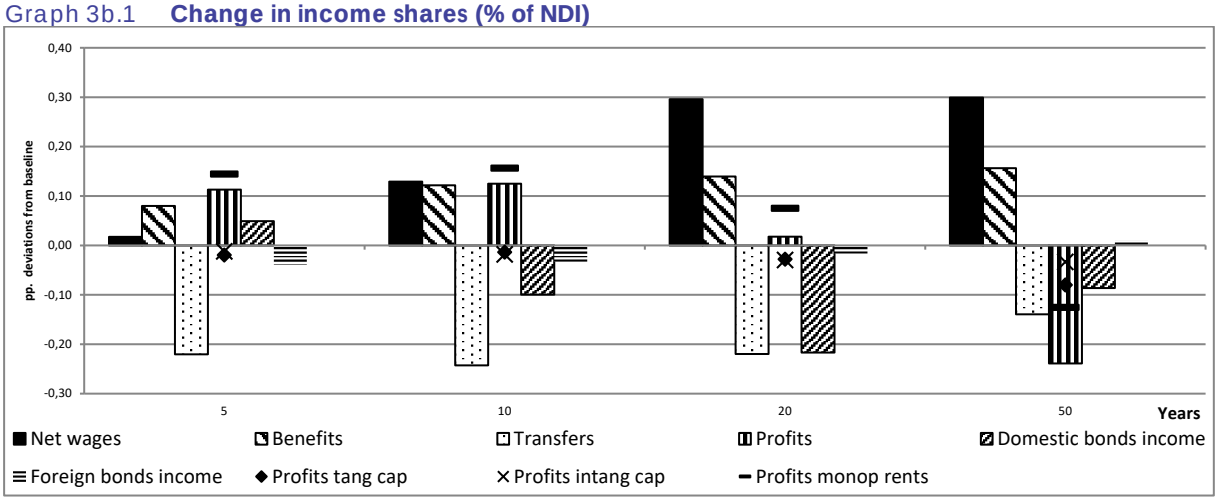
The share of net wages in net disposable income rises (panels 3.1 and 3.3). The share of transfers in disposable income falls (panel 3.1) as in scenario 4.1.1 above, because (real) transfers are kept constant in absolute volumes and, hence, decline relative to total income in the context of total income growth. The capital income share rises mostly because of an increase in monopoly rents. This is attributable to a scale effect. An expansion of output (higher labour input) reduces the share of fixed costs in production, leading to higher profits. Declining returns on tangible and intangible capital lead to a decline of the share of firm profits in the long run, however. The falling share of income on domestic bonds (panel 3.1) follows from the lower nominal interest rates associated with an accommodative monetary policy response to positive supply shocks, and of a reduction in the level of government debt.

Allowing for firm entry

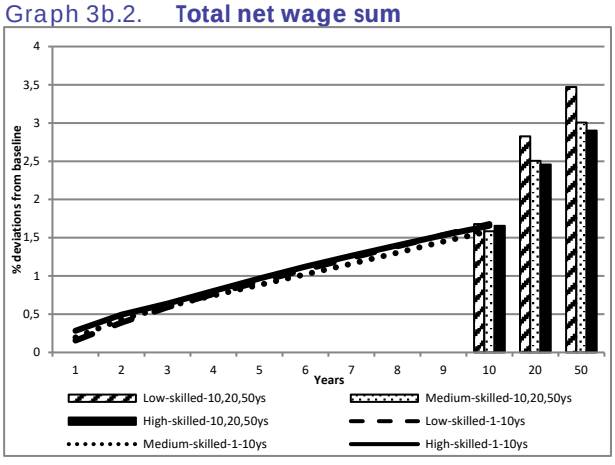
As sensitivity analysis, we have also simulated an alternative scenario of the reform that allows for an endogenous decline of mark-ups (stronger firm entry) in response to the initial increase in monopoly rent. The results are displayed in Graphs 3.b and show that the profit income share declines more sharply in the long term in this case, at the benefit of a higher wage income share.[5] This shows an important implication for the design and sequencing of reforms. Labour market reforms combined with existing goods market rigidities can lead to suboptimal distributional effects in terms of a relative increase in the profit share. The relative increase in the capital income share associated with labour market reforms can only be reduced if we allow for entry in the goods market. The result echoes the finding in Blanchard and Giavazzi (2003) that labour market reform without product market reform, which lowers the bargaining power of workers, redistributes product market rents from labour to capital without lowering the total size of the rents. This suggests that labour market reforms may lead to suboptimal distributional effects if there are rigidities in goods markets present, a finding which confirms the importance of ensuring that such reforms are accompanied or preceded by product market reforms.[6]

Graph 3b. **Increase in female participation - with entry**

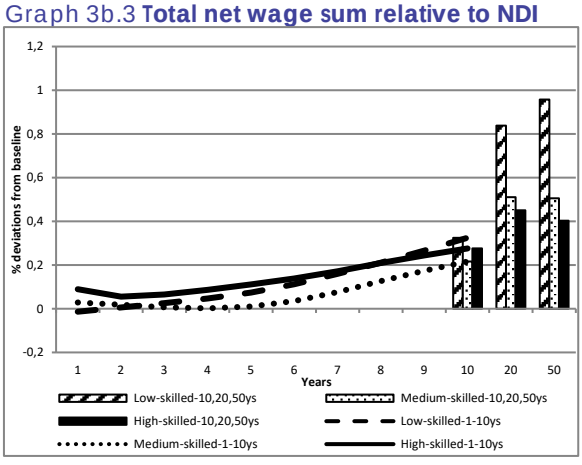
Graph 3b.1 **Change in income shares (% of NDI)**



Graph 3b.2. **Total net wage sum**



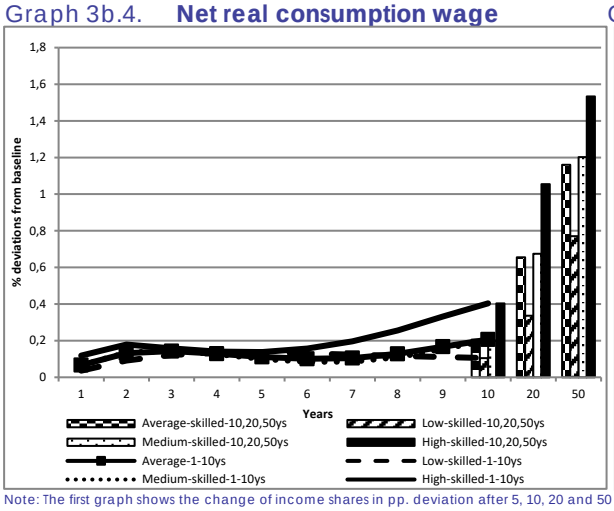
Graph 3b.3 **Total net wage sum relative to NDI**



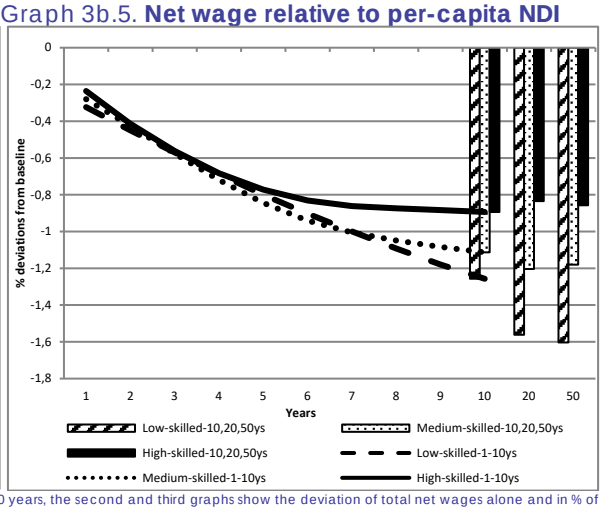
[5] In this scenario we endogenise services mark-ups (mup_t^Y) in order to mimic the endogenous entry of new firms via the return of monopoly rents (*m.rent*) towards their baseline level ($\overline{m.rent}$), i.e. mark-ups decline in response to an increase in monopoly rents: $mup_t^Y = mup_{t-1}^Y - \gamma(m.rent - \overline{m.rent})$, where $\gamma > 0$.

[6] See e.g Berti and Meyermans (2017).

Graph 3b.4. **Net real consumption wage**



Graph 3b.5. **Net wage relative to per-capita NDI**



Note: The first graph shows the change of income shares in pp. deviation after 5, 10, 20 and 50 years, the second and third graphs show the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

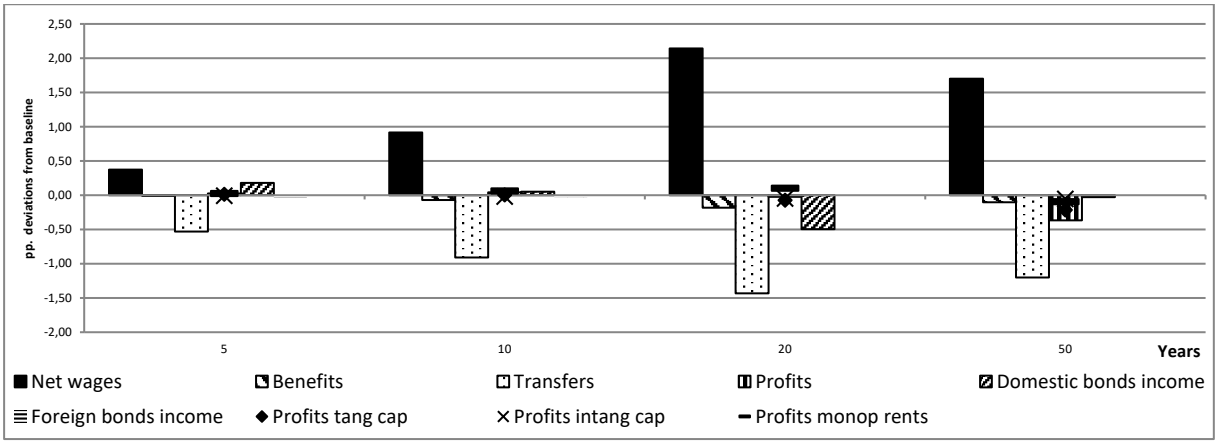
Source: Commission services

4.1.3 Older workers' participation

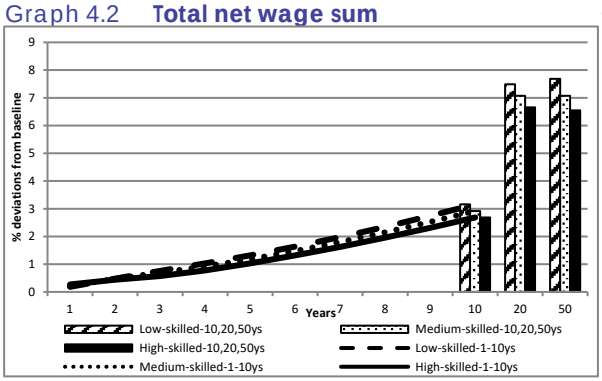
The third participation scenario is related to the 55-65 year age group. Here, the simulated reform is an increase in the participation rate for this age group by 2 pp, which has a bias towards higher participation of lower skilled. Higher labour force participation in this age group (lower early retirement) implies a decline in transfer (pension) payments, as shown in Graph 4, and also a more favourable net wage income share development, following higher employment and a lower tax burden on labour, while other income, with the exception of transfers (which include pensions), are little affected.

Graph 4. **Increase in old-age labour force participation**

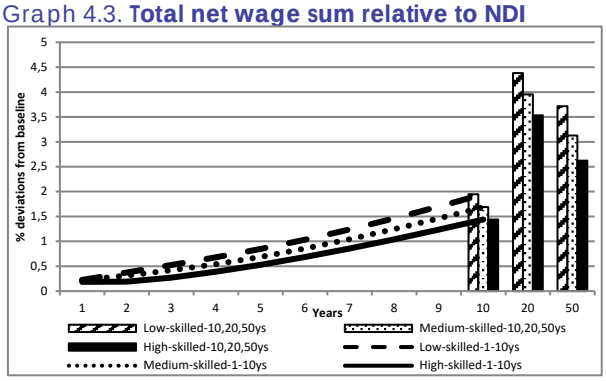
Graph 4.1. **Change in income shares (% of NDI)**



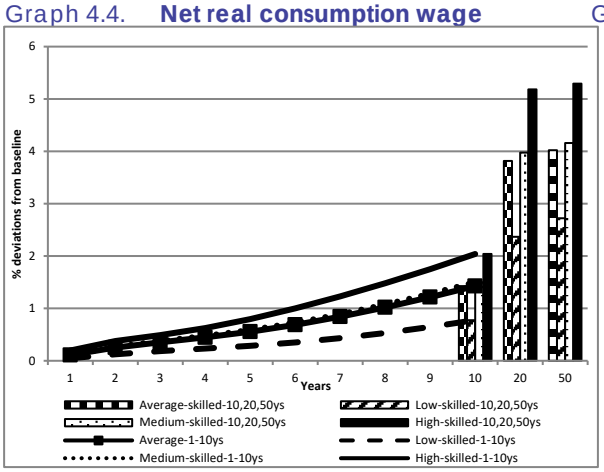
Graph 4.2 **Total net wage sum**



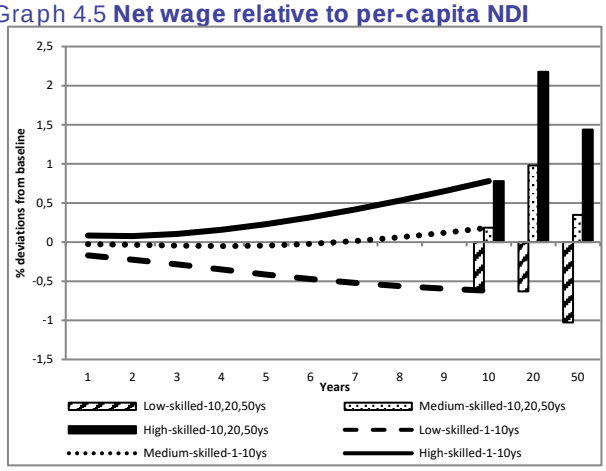
Graph 4.3. **Total net wage sum relative to NDI**



Graph 4.4. **Net real consumption wage**



Graph 4.5 **Net wage relative to per-capita NDI**



Note: The first graph shows the change of income shares in pp. deviation, the second and third graphs shows the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

Source: Commission services

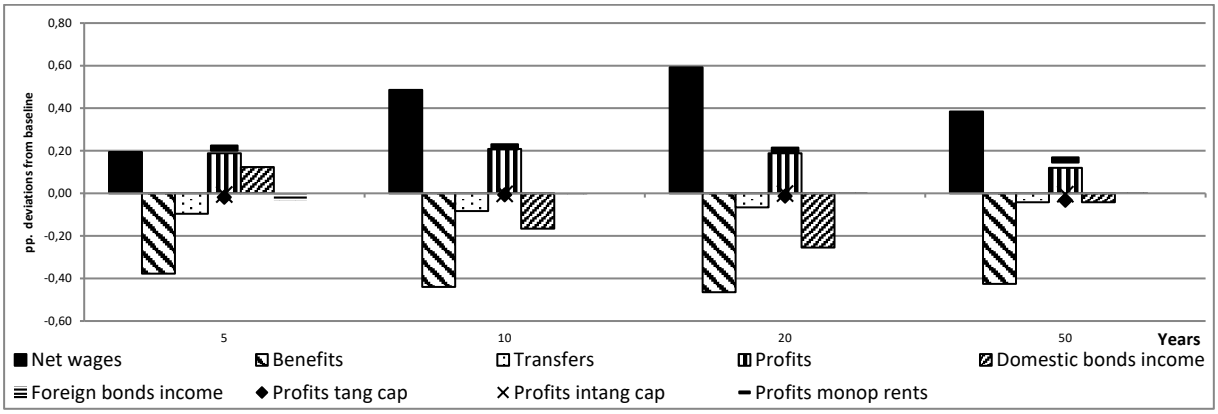
Less early retirement of workers implies that the wage sum increases in all skill categories (panels 4.2 and 4.3). The relative wage for low-skilled workers declines due to the low-skilled bias in the participation increase (panel 4.5). The sizable reduction in the labour income tax, to rebate budgetary savings on pensions, implies a wage increases in real consumption terms for all skill groups (panel 4.5), which together with higher employment drives the increase in the net wage share in NDI (panel 4.1). The labour tax reduction associated with lower government spending on pensions is much more pronounced that the one associated exclusively with tax base growth in section 4.1.1 and 4.1.2, which explains the stronger net wage growth in particular in comparison to 4.1.2.

4.2 BENEFIT REFORMS

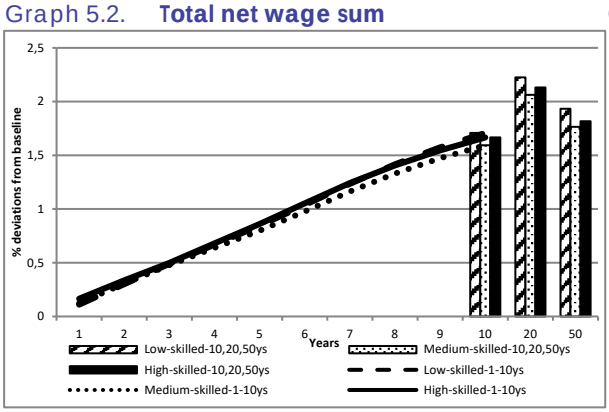
Benefit reform as simulated in Graph 5 is a reduction in unemployment benefits. The initial policy impulse is a reduction in the benefit replacement rate by 3.5 pp at the EU level. The reduction shifts income from benefits to wages (panel 5.1). The main effect is an increase in employment generated by lower wage claims, i.e. a labour supply expansion associated with a reduction of the reservation wage. the net real consumption wage increases for all skill groups due to a reduction in the labour tax (budgetary savings from less benefit payments are rebated through the tax cut) and a fall in the price level (lower production costs). Income from financial wealth and capital income increases slightly as well, because increased labour supply (lower wages) increases investment in physical capital and intangible assets (entry of new firms). The capital income share rises mostly because of an increase in monopoly rents. The increase in monopoly rents is largely due to a scale effect, i.e. an expansion of output (higher labour input) which reduces the share of fixed costs in production.

Graph 5. **Reduction in benefit replacement rate**

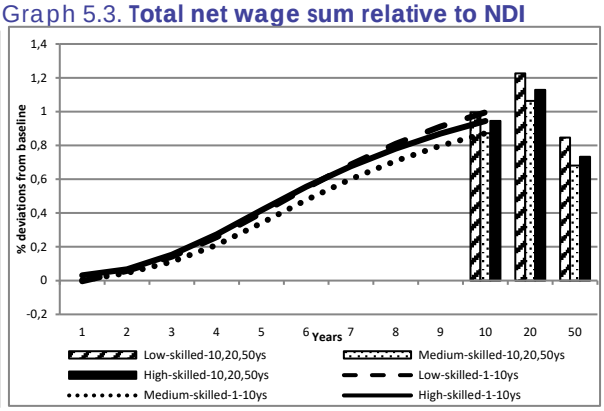
Graph 5.1. **Change in income shares (% of NDI)**



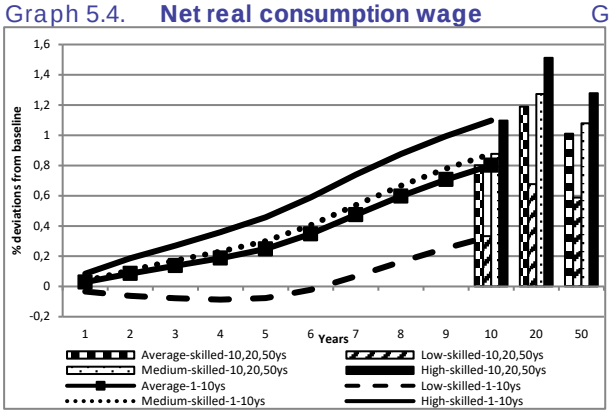
Graph 5.2. **Total net wage sum**



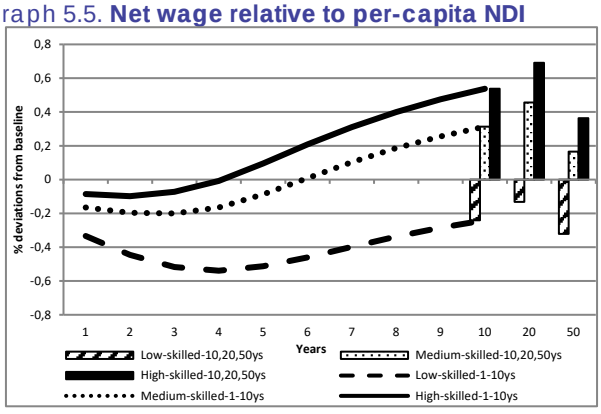
Graph 5.3. **Total net wage sum relative to NDI**



Graph 5.4. **Net real consumption wage**



Graph 5.5. **Net wage relative to per-capita NDI**



Note: The first graph shows the change of income shares in pp. deviation after 5, 10, 20 and 50 years, the second and third graphs show the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

Source: Commission services

4.3 EDUCATION REFORMS

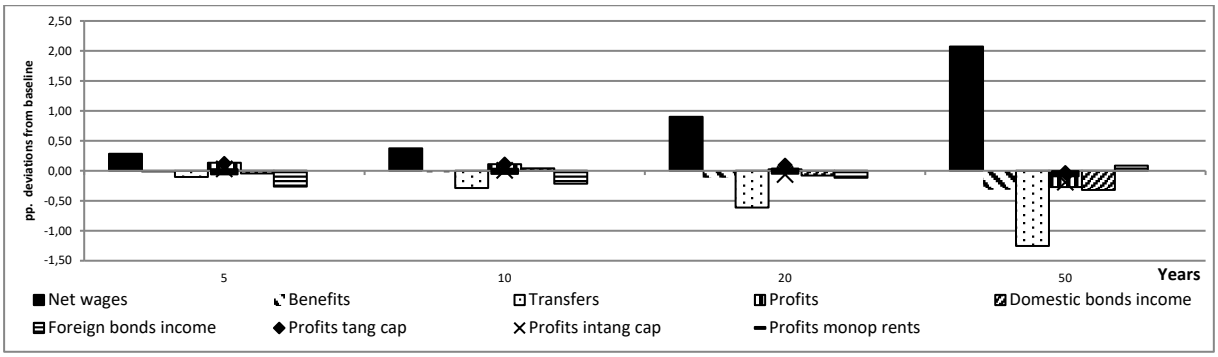
4.3.1 Increasing the share of high-skilled

Changes in education and their effects on the quality of the labour force can be captured in the model as (gradual) changes in the skill composition. Thus, in this exercise human capital investment is modelled as changing the relative weights of the different skill categories. The first type of education re-

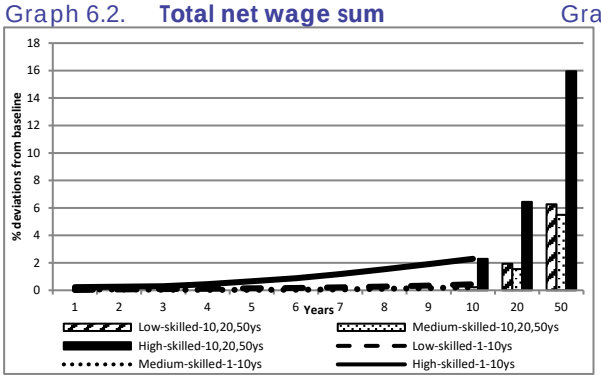
form we consider is an increase in the share of high-skilled by 2.2 pp and a corresponding decline in the share of medium-skilled. There is a direct productivity effect from this as high-skilled workers are more productive, but the shift in skill shares is introduced very gradually to capture the fact that it can be brought about only through education and training and will, hence, take time. As these reforms will have costs, the higher costs of tertiary education (compared to benchmark spending on this) are also taken into account. The simulation results for income categories are summarised in Graph 6.

Graph 6. **Increase in share of high-skilled**

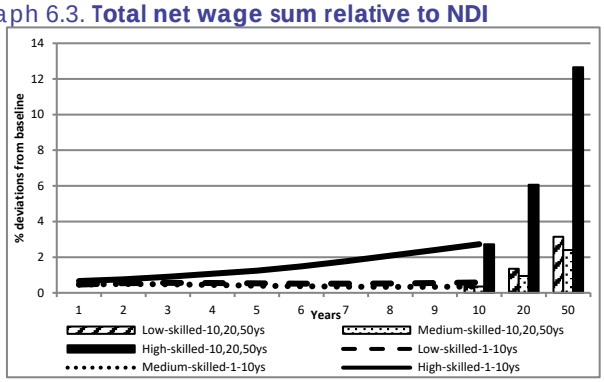
Graph 6.1. **Change in income shares (% of NDI)**



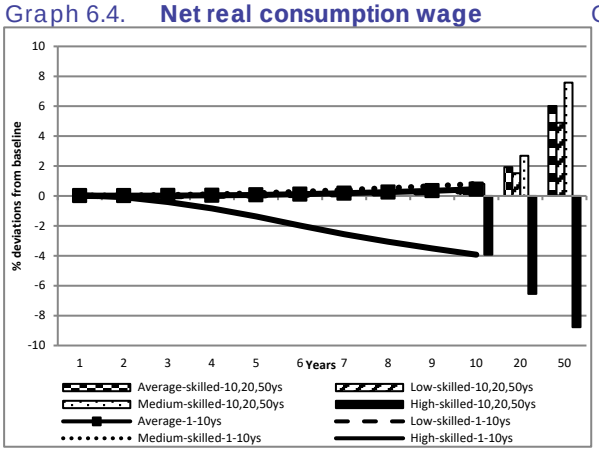
Graph 6.2. **Total net wage sum**



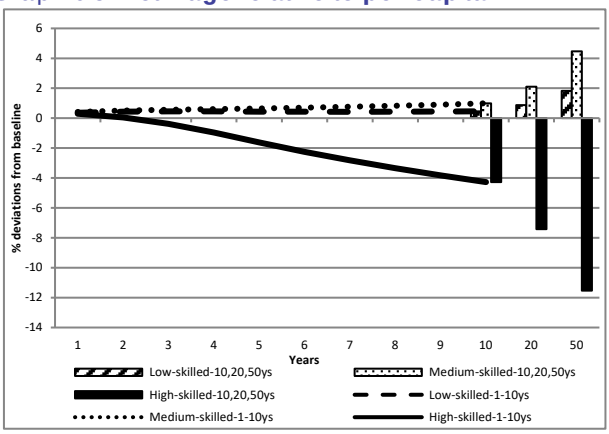
Graph 6.3. **Total net wage sum relative to NDI**



Graph 6.4. **Net real consumption wage**



Graph 6.5 **Net wage relative to per-capita NDI**



Note: The first graph shows the change of income shares in pp. deviation, the second and third graphs shows the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

Source: Commission services

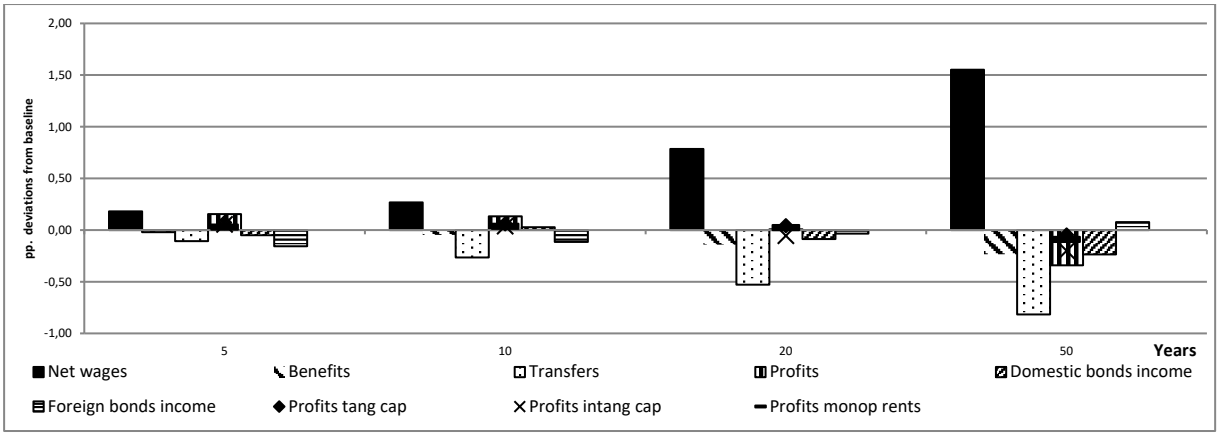
Higher supply of high-skilled workers increases the supply of intangible capital and leads to entry of new firms. This increases the share of intangible capital income. For the highly skilled there are clear

trade offs as an increase in the high-skilled labour force is associated with a decline in their real wage (panels 6.4 and 6.5). However, there is a tendency towards an increase in the wage sum and the relative wage share of high-skilled workers (panels 6.2 and 6.3), which is explained by an increase in the demand for high-skilled workers that depends on the elasticity of substitution (μ=1.7 in the simulations) between the three skill-types in the production function (see equation 26). Note that an elasticity of μ<1 could result in a simultaneous decline of high-skilled real wages and relative wage shares after an increase in their population share (Graph 6.b).

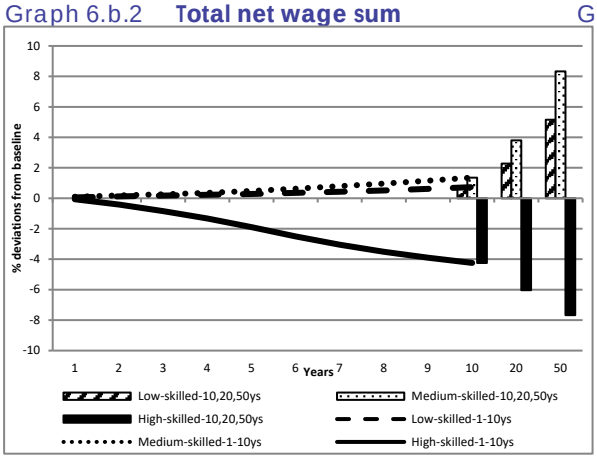
The higher increase in the net wage share in NDI (panel 6.1) is furthermore is due to the fact that, despite the decline in real wage for highly skilled, high-skilled wage levels are still above wage levels for medium- and low-skilled workers. Shifting workers into a higher skill group therefore increases average labour income. In case of lower substitutability between skill groups and a decline in the high-skilled wage sum (Graph 6.b), the overall increase in the wage share is smaller than that with the higher benchmark elasticity. The decline in the transfer income share (panel 6.1) is explained, as before, by the fact that transfers are kept constant in real volumes, so that their relative importance falls when other income grows.

Graph 6.b. **Increase in share of high-skilled – low elasticity**

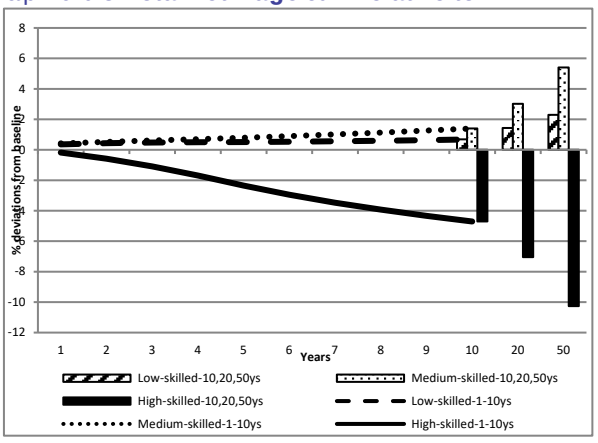
Graph 6.b.1 **Change in income shares (% of NDI)**



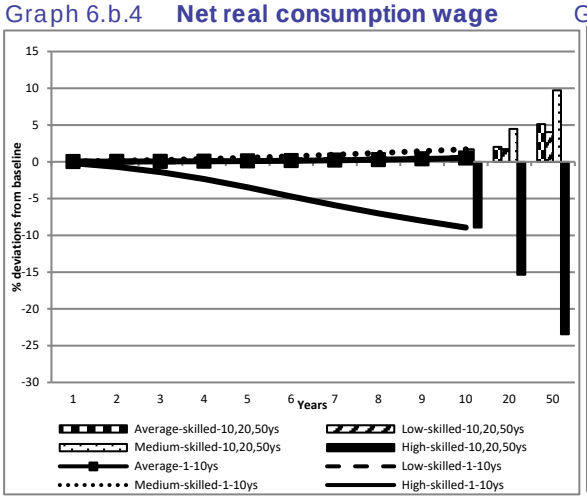
Graph 6.b.2 **Total net wage sum**



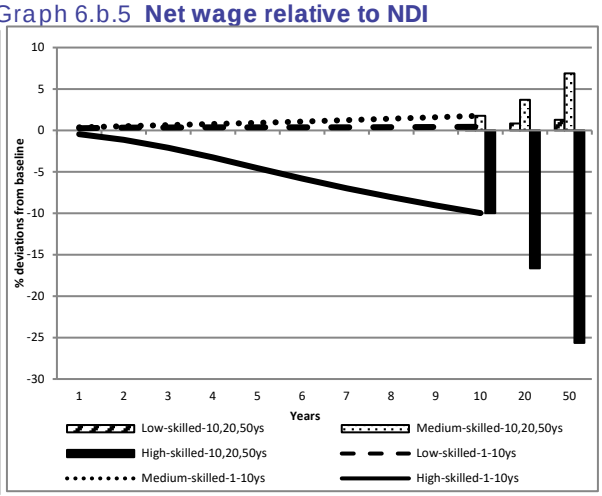
Graph 6.b.3 **Total net wage sum relative to NDI**



Graph 6.b.4 **Net real consumption wage**



Graph 6.b.5 **Net wage relative to NDI**



Note: The first graph shows the change of income shares in pp. deviation, the second and third graphs shows the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

Source: Commission services

4.3.2 Increasing the share of medium-skilled

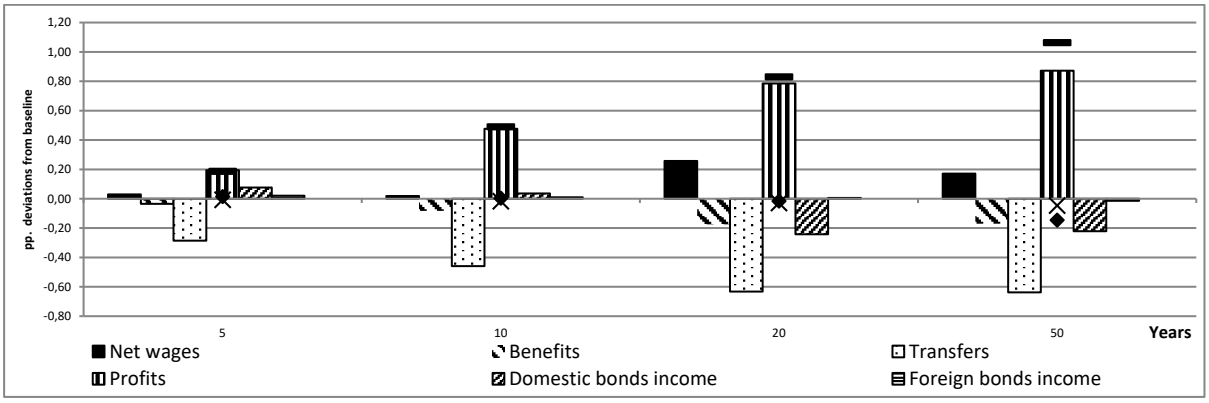
The second human capital investment reform we consider is an increase in the share of medium-skilled workers, as a shift from low-skilled (Graph 7). The increase of the average skill level in the economy (reducing the proportion of low-skilled) is modelled as a gradual change, accounting for the substantial lags in achieving that objective, including lags in reforming the education system and the gradual passing through of new cohorts onto the labour market. The reform cost is modelled as an increase in education-related expenditure. In this reform the share of medium-skilled increases by 12.4 pp on average in the EU. The simulation results for income categories are summarised in Graph 7.

Again, we see a trade-off between employment expansion and wage decline for (this time) the medium skilled, and for the low-skilled the opposite, i.e. a lower employment share and an increase in their wage. For the benchmark substitution elasticity between skills groups (μ=1.7), the medium-skilled wage sum as well as the income share increase and the low-skilled ones declines (panels 7.2 and 7.3).

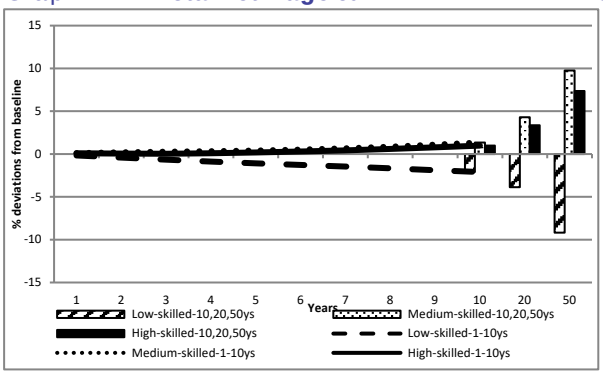
The decline of the transfer income share (panel 6.1) is explained, as before, by the fact that transfers are kept constant in real volumes, so that their relative importance falls when other income grows. Most strikingly, however, the reform scenario implies an increase in the capital share in total income that is driven by increasing monopoliy rents (scale effect of lower average fix costs). The result depends crucially on the assumption of no entry. When we allow for entry, implemented by a mark-up reduction which responds endogenously to the rents following the same equation as in footnote 4 with the female participation rate shock, the increase in the profit share is much reduced, at the benefit of a higher wage share (Graph 7.b).

Graph 7. **Increase in share of medium-skilled "without entry"**

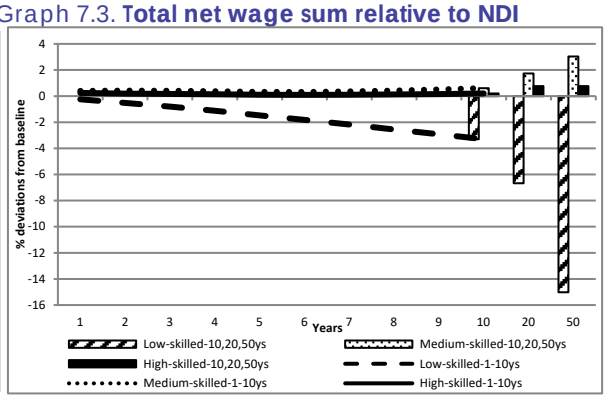
Graph 7.1. **Change in income shares (% of NDI)**



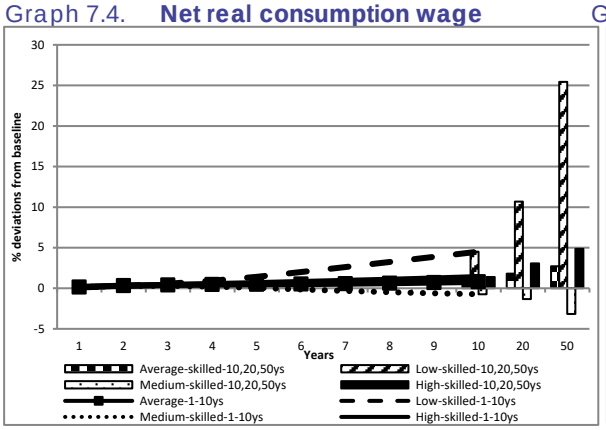
Graph 7.2. **Total net wage sum**



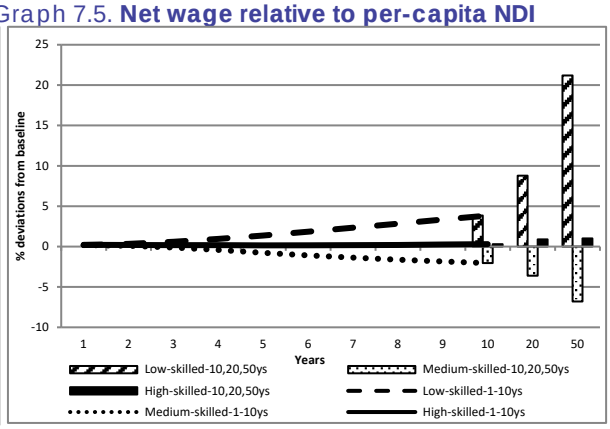
Graph 7.3. **Total net wage sum relative to NDI**



Graph 7.4. **Net real consumption wage**



Graph 7.5. **Net wage relative to per-capita NDI**

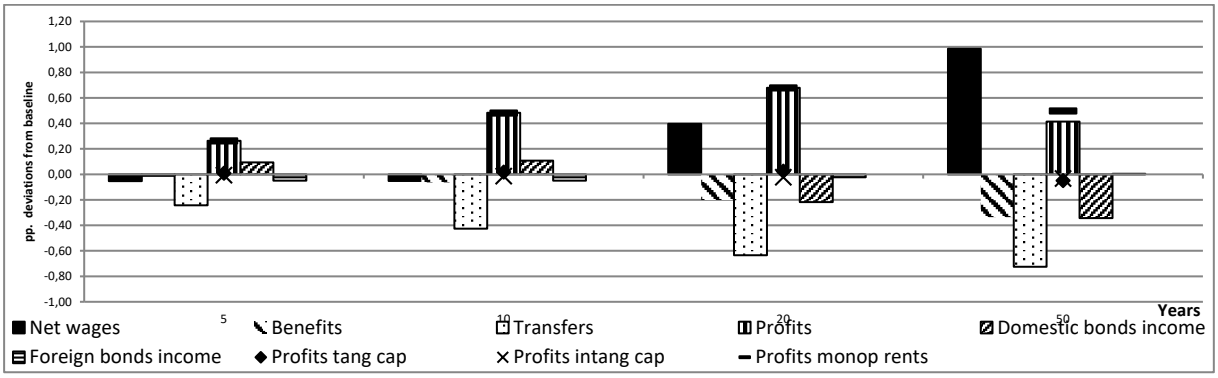


Note: The first graph shows the change of income shares in pp. deviation, the second and third graphs shows the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

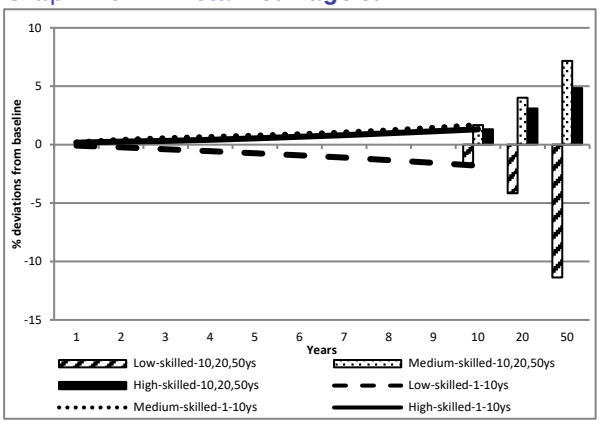
Source: Commission services

Graph 7.b. **Increase in share of medium-skilled - "with entry"**

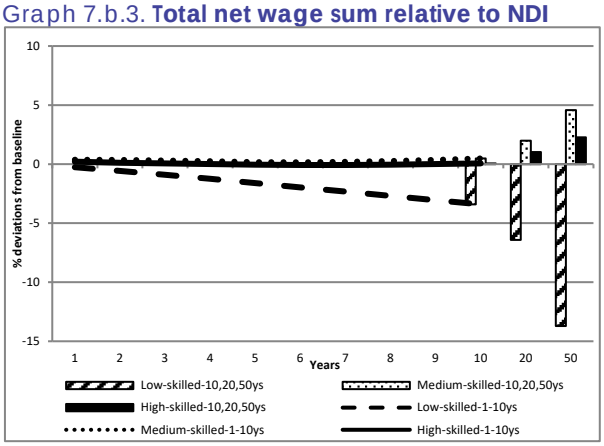
Graph 7.b.1. **Change in income shares (% of NDI)**



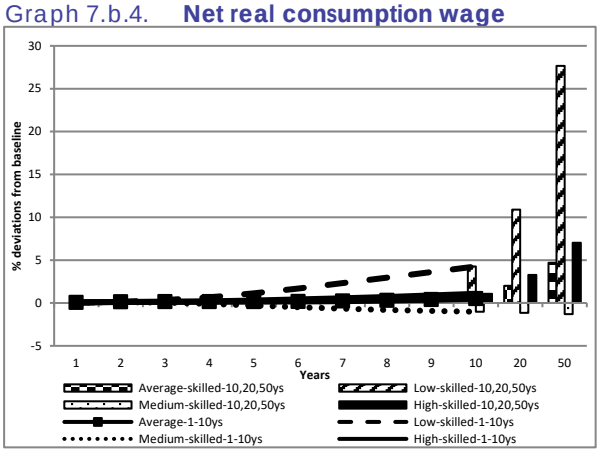
Graph 7.b.2. **Total net wage sum**



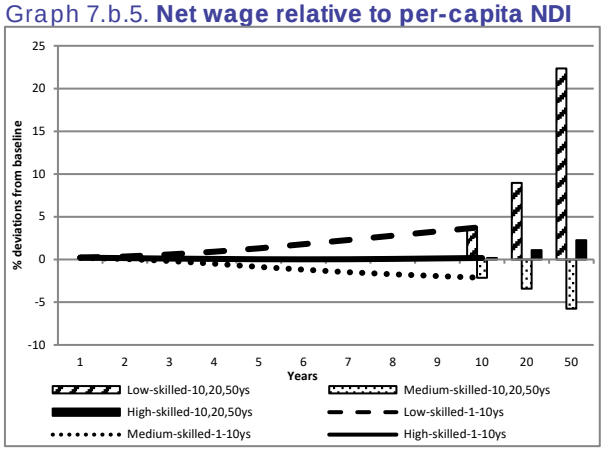
Graph 7.b.3. **Total net wage sum relative to NDI**



Graph 7.b.4. **Net real consumption wage**



Graph 7.b.5. **Net wage relative to per-capita NDI**



Note: The first graph shows the change of income shares in pp. deviation, the second and third graphs shows the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

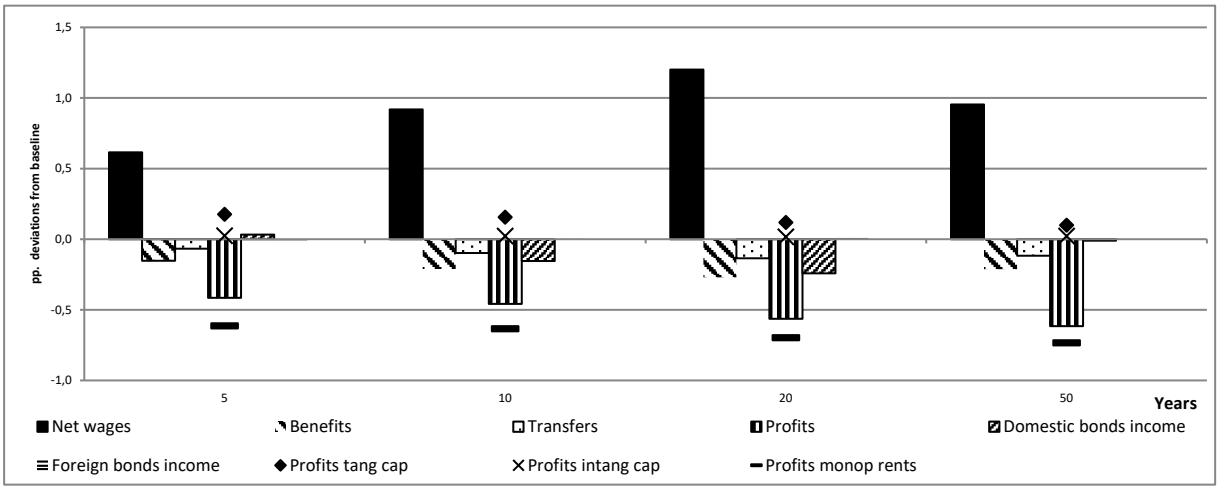
Source: Commission services

4.4 PRODUCT MARKET REFORMS: SERVICES MARK-UPS

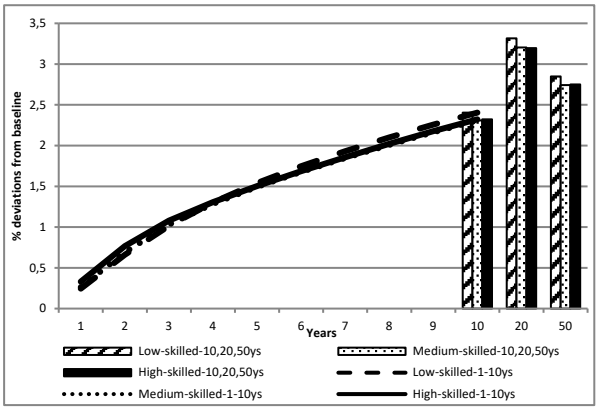
Product market reforms aim to increase competition, which puts pressure on firms to reduce mark-ups and lower their prices. This in turn raises output and increases demand for all factors of production (tangible capital, intangible capital, and labour) in the medium term. The simulated mark-up shock corresponds to 1.5 pp lower services mark-ups at the EU level.[7] The combination of price declines and increased factor demand raise wage income due to higher employment and real wages (see Graphs 8.2-8.5 below) while the share of profit income is shrinking (Graph 8.1). The share of transfers to households is also falling slightly as a percentage of net disposable income, because the transfers volume is kept constant in absolute terms, whereas the share of unemployment benefits falls more strongly as employment increases.

Graph 8. **Services mark-up shocks**

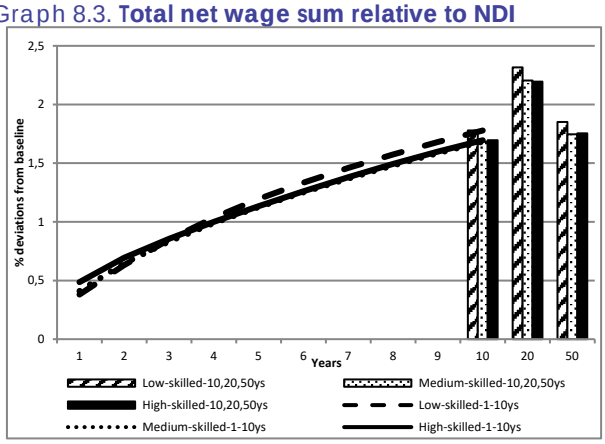
Graph 8.1 **Change in income shares (% of NDI)**



Graph 8.2. **Total net wage sum**

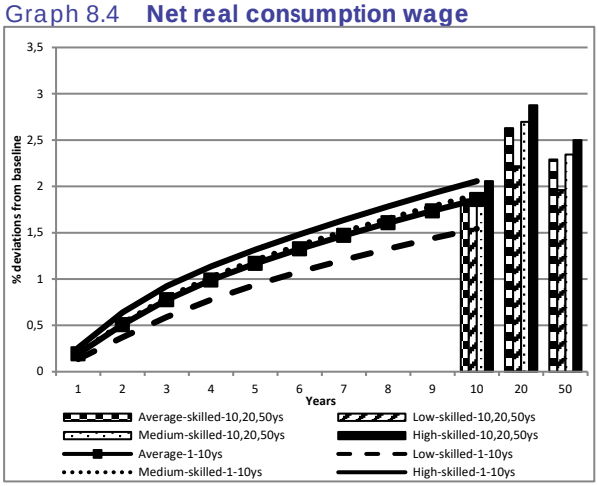


Graph 8.3. **Total net wage sum relative to NDI**

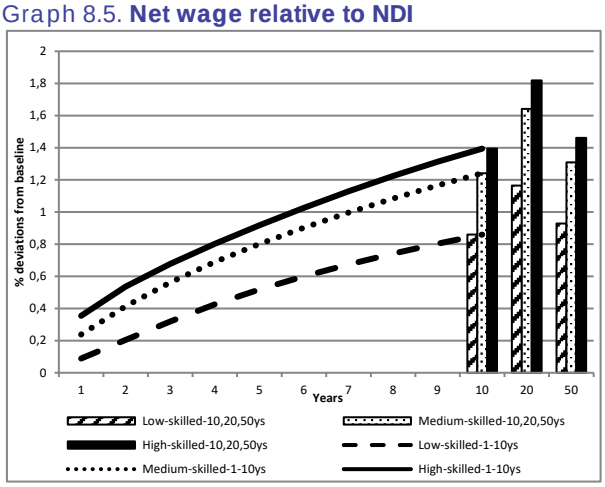


[7] In the model, this shock is given to the final goods sector. As this sector also includes manufacturing sectors, the shock is scalled down to fit the services sector.

Graph 8.4 **Net real consumption wage**



Graph 8.5. **Net wage relative to NDI**

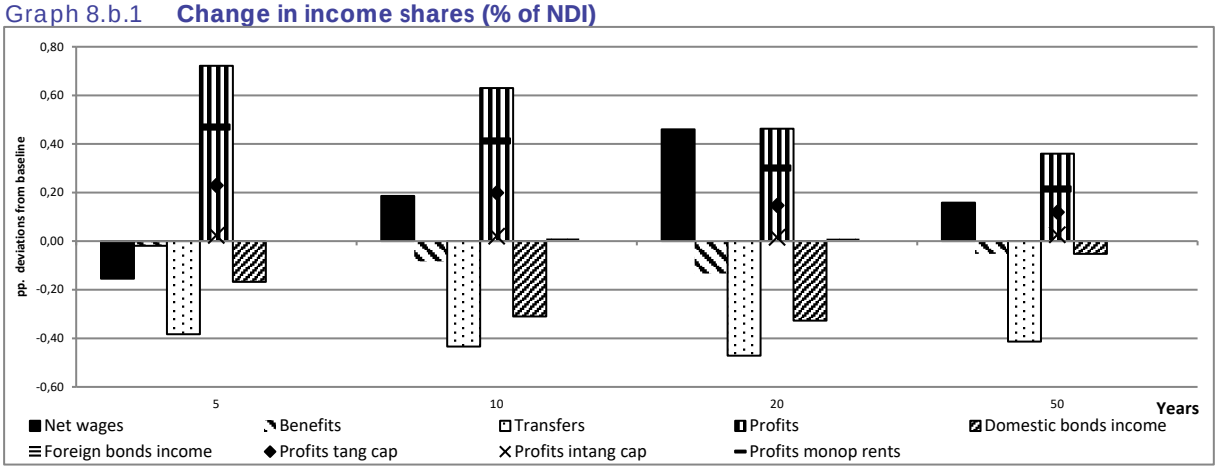


Note: The first graph shows the change of income shares in pp. deviation after 5, 10, 20 and 50 years. The second and third graphs show the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

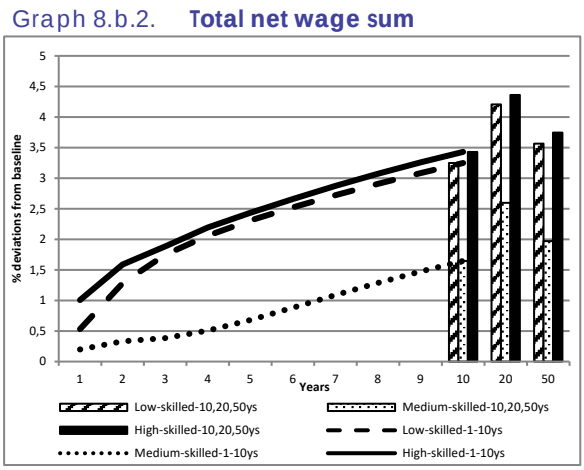
Source: Commission services

Graph 8.b. **Services mark-up shocks with overhead labour cut**

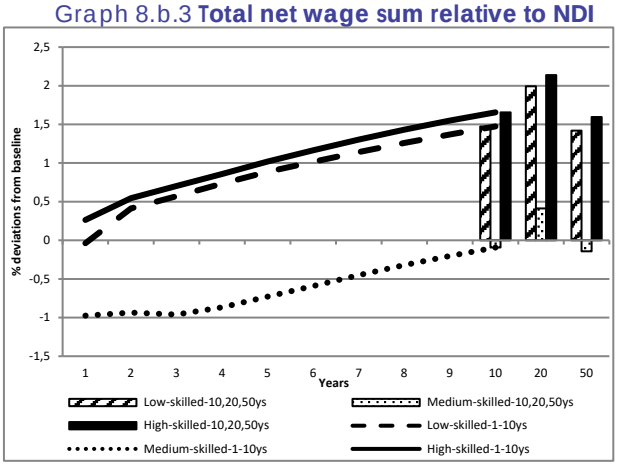
Graph 8.b.1 **Change in income shares (% of NDI)**



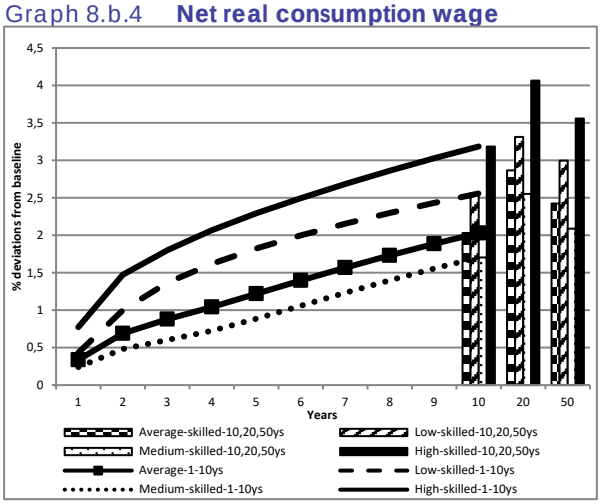
Graph 8.b.2. **Total net wage sum**



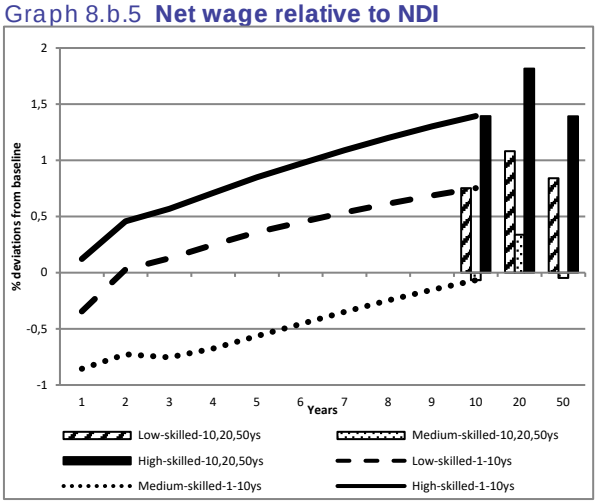
Graph 8.b.3 **Total net wage sum relative to NDI**



Graph 8.b.4 **Net real consumption wage**



Graph 8.b.5 **Net wage relative to NDI**



Note: The first graph shows the change of income shares in pp. deviation after 5, 10, 20 and 50 years, the second and third graphs show the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

Source: Commission services

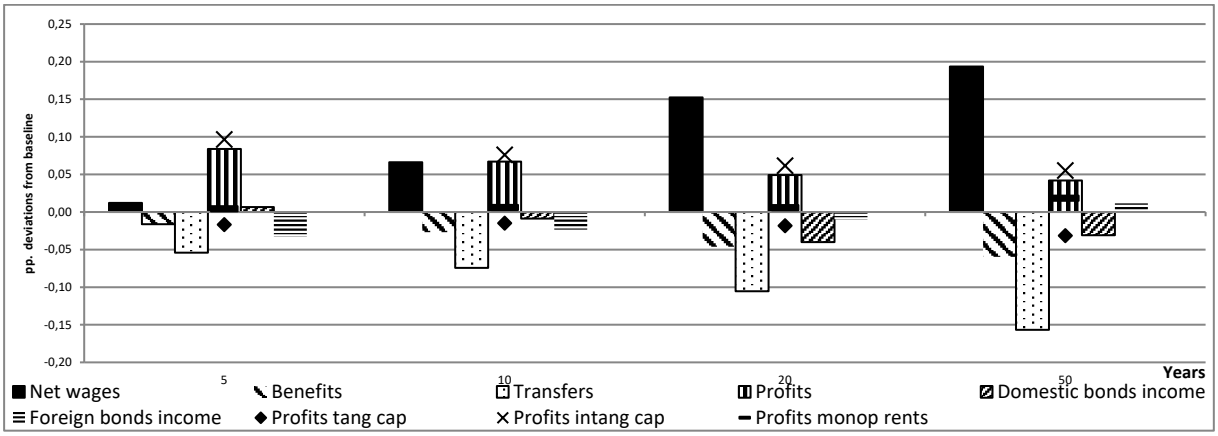
However, this scenario does not take into account that, in the short run, increased competition also reduces the profitability of less productive firms and induces lay-offs. While the destruction of existing jobs is immediate, job creation is only gradual. Therefore, the unemployment rate is likely to first increase before it declines gradually as new jobs are created (see Cacciatore and Fiori, 2016). In order to incorporate this element of the reform we run a slightly modified version of the scenario with proportionally decreasing overhead labour costs to account for the job losses in the services sector. The corresponding simulation results in Graphs 8.b.1-8.b.5 show that product market reforms can be less favourable in terms of wage income. The decrease in overhead labour is assumed to be restricted to medium-skilled labour, and this skill group faces an initial decline in their relative wage share. Overall the share of wages is initially shrinking and only later increasing, but by less than in the previous scenario, while the profit share in income is actualy increasing. The income shares of benefits and (constant) transfers decline again in the context of higher employment, wage sums, and profits. Interest income on bond holdings also declines in relative terms, which also relates to the accommodative monetary policy response to positive supply shocks.

4.5 PRODUCT MARKET REFORMS: ENTRY BARRIERS

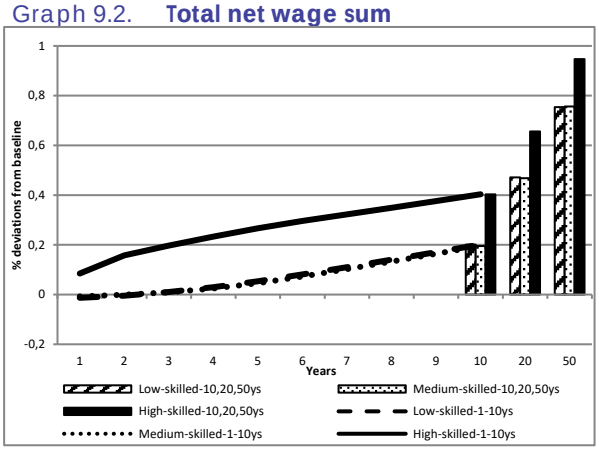
This reform scenario was simulated as a decrease in administrative entry costs of 3 pps on average for the EU in terms of income per capita. Reducing administrative entry barriers increases the entry of new firms by lowering profit requirements to cover initial costs. Decreasing the entry costs for new intermediate firms leads in the model to an increase in demand for patents as each firm needs a new product variety. Patents are produced by the research sector, which has to hire more researchers to satisfy demand and has to offer higher wages to attract these researchers. Increased final production also raises the demand for medium-skilled who are the closest substitute to the high-skilled workers that leave the final goods sector for the research sector. Real wages and total net real wages are increasing, especially for the high-skilled. There is a strong shift towards net wages in the share of total net disposable income relative to the other income categories.

Graph 9. **Reducing administrative entry costs**

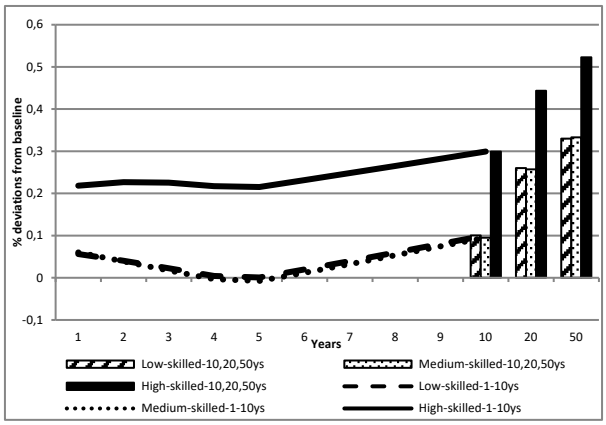
Graph 9.1. **Change in income shares (% of NDI)**



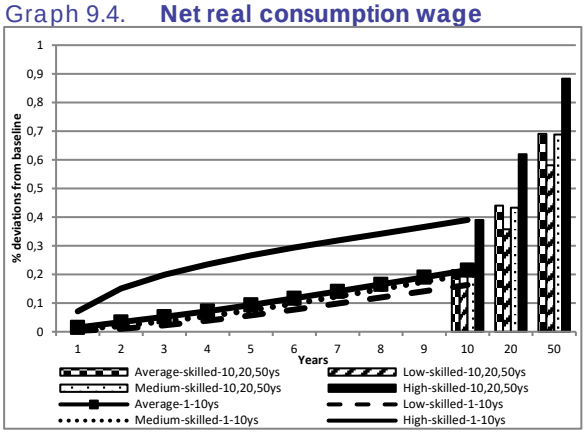
Graph 9.2. **Total net wage sum**



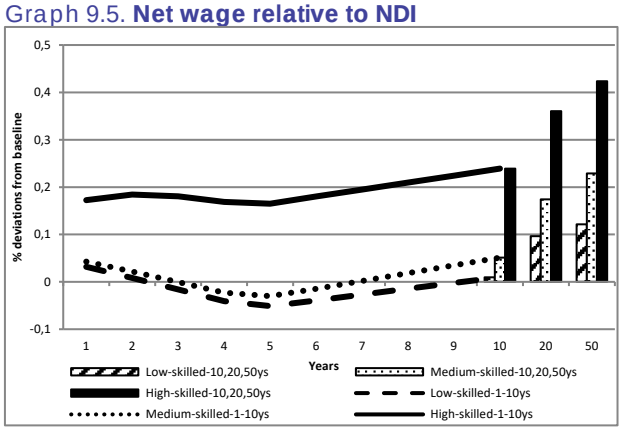
Graph 9.3. **Total net wage sum relative to NDI**



Graph 9.4. **Net real consumption wage**



Graph 9.5. **Net wage relative to NDI**



Note: The first graph shows the change of income shares in pp. deviation after 5, 10, 20 and 50 years, the second and third graphs show the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

Source: Commission services

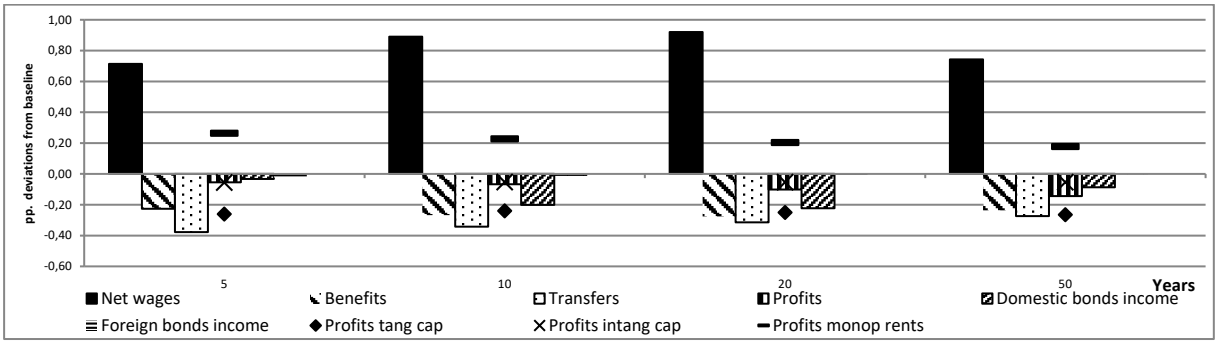
4.6 TAX REFORMS

Reducing labour income taxes and rasing consumption taxes in a revenue neutral way shifts the burden of taxation from labour to all sources of income, including income from financial and non-financial wealth. Such a tax shift redistributes real consumption income from capital owners to wage earners

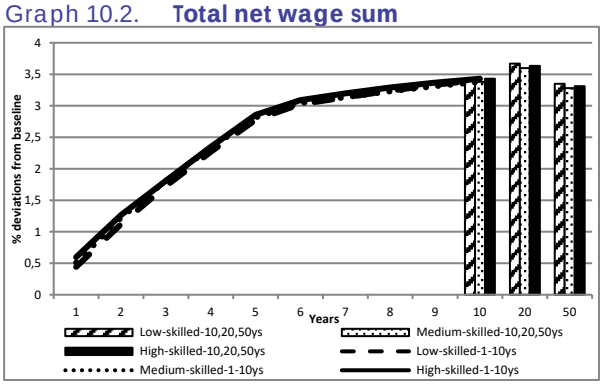
(see Burgert and Roeger, 2014). The scenario simulated corresponds to a 4% of GDP shift from labour to consumption taxes on average. The tax-shift makes returns to labour income more attractive and boosts employment, particularly for the low-skilled, who have a higher wage elasticity of labour supply. Graph 10 shows that net wage income shares are increasing, whereas the shares of other income sources fall. Concerning social transfer income, the tax shift is regressive, especially in a situation in which transfer income recipients are not compensated for the increase in the VAT. This adverse effect on benefit recipients is partly alleviated by a positive employment effect, which moves unemployed workers into employment. The effects thus depend on how different income groups are compensated for the consumption tax increase. In particular, if unemployment benefits and other transfers are indexed to consumer prices, the positive effects on employment and the wage income share will be smaller, and the transfer and benefit income shares will fall by less.

Graph 10. **Tax shift from labour to consumption**

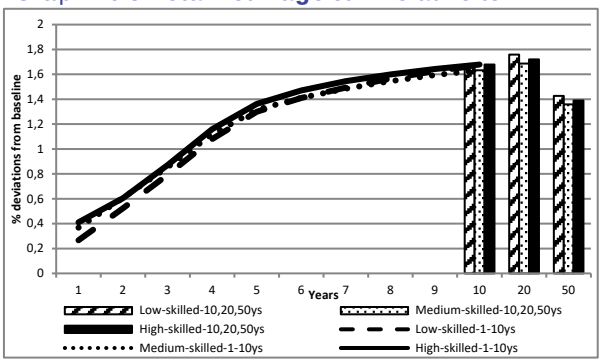
Graph 10.1. **Change in income shares (% of NDI)**



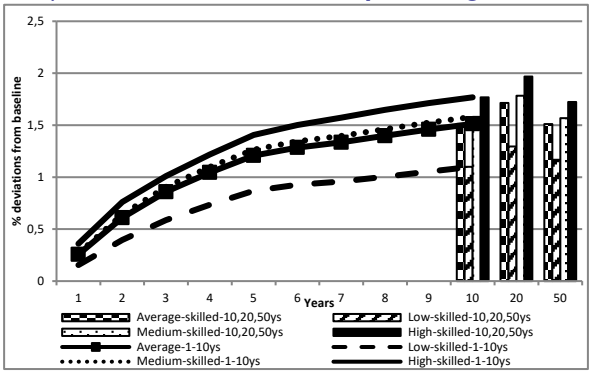
Graph 10.2. **Total net wage sum**



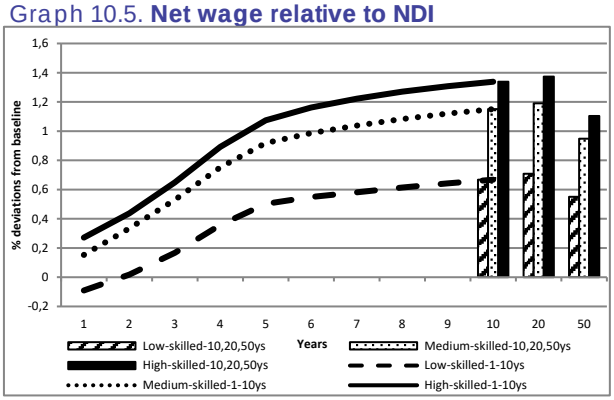
Graph 10.3. **Total net wage sum relative to NDI**



Graph 10.4. **Net real consumption wage**



Graph 10.5. **Net wage relative to NDI**



Note: The first graph shows the change of income shares in pp. deviation after 5, 10, 20 and 50 years, the second and third graphs show the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

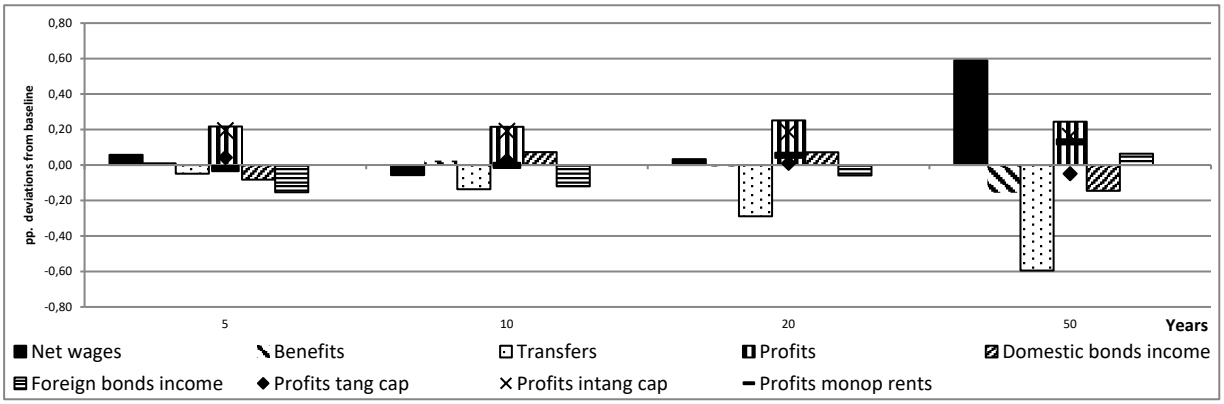
Source: Commission services

4.7 INNOVATION SUBSIDIES

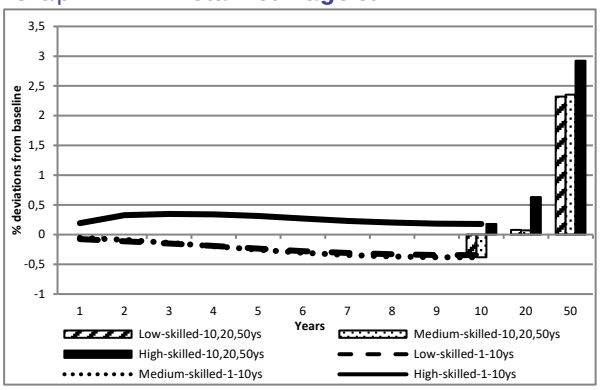
The innovation subsidy considered in this final reform scenario is an increase in the tax credit rate for R&D spending by around 6.6 pp at the EU aggregate level. This tax credit raises R&D, and, as Graph 11 shows, this mostly benefits high skilled workers and income from intangible assets, which is part of the profit revenue in Graph 11.1. High-skilled wages increase relative to other skills. The increase in income shares for wage income and intangible capital is mainly at the expense of transfer income (not indexed to wages and GDP). The skill premium increases because of an increase for high-skilled workers in the context of increasing R&D. Since higher R&D increases intangible assets, income from intangibles increases. There is also a direct effect on income from intangibles from the R&D subsidy.

Graph 11. **R&D subsidy**

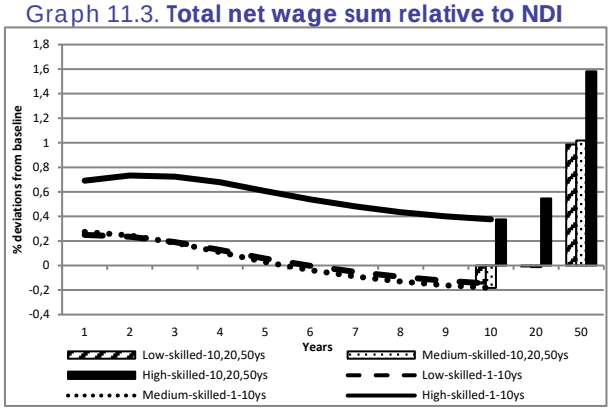
Graph 11.1. **Change in income shares (% of NDI)**



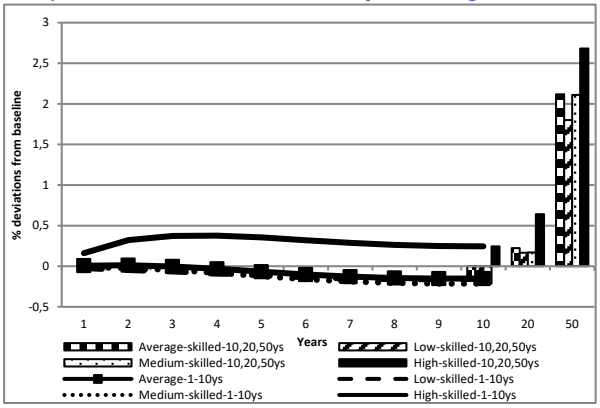
Graph 11.2. **Total net wage sum**



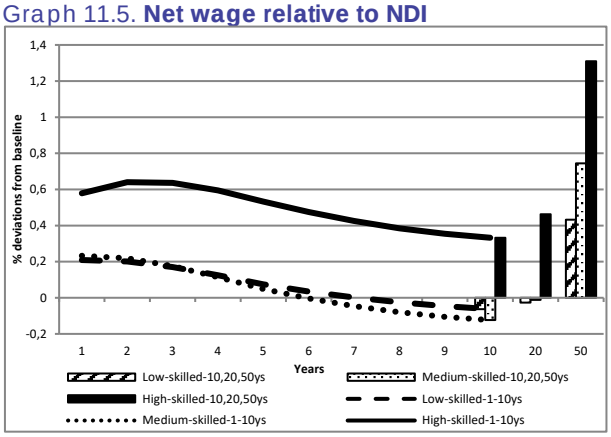
Graph 11.3. **Total net wage sum relative to NDI**



Graph 11.4. **Net real consumption wage**



Graph 11.5. **Net wage relative to NDI**



Note: The first graph shows the change of income shares in pp. deviation, the second and third graphs shows the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

Source: Commission services

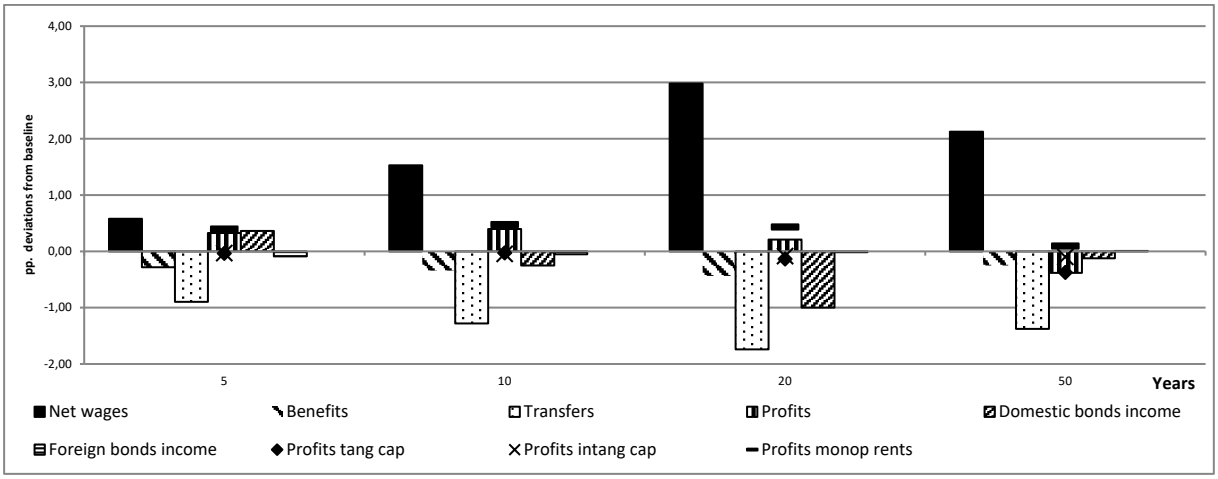
4.8 TWO BROAD GROUPS OF REFORMS

As a way of summarising the results, we group our structural reforms into two sets of reforms. The first set aims at increasing the employment rate and combines the effects of benefit reductions and increasing female labour force participation as well as those of the 55-65 age group (as in section 4.1 and 4.2). [8] The results are summarised in Graph 12 below. The second type of reforms merges the effect of reforms that increase the share of high- and medium-skilled workers via spending on education, and also includes innovation subsidies (as in section 4.3 and 4.7). Graph 13 reports the results for this package.

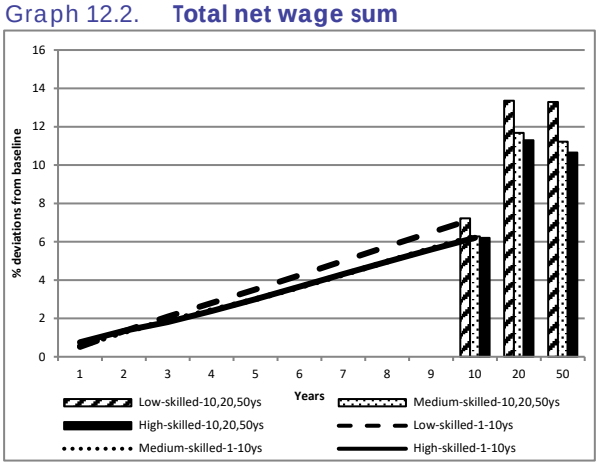
The first group of reforms leads to a significantly larger increase in the wage share in the short- and medium run, whereas in the long run the wage share increases more in the package focussing on skills. It takes longer before the benefits of human capital investment become apparent, however. The reforms focused on innovation and human capital improvement have a stronger positive impact on the profit share, in particular for intangible capital.

Graph 12. **Labour market reforms (participation-focussed)**

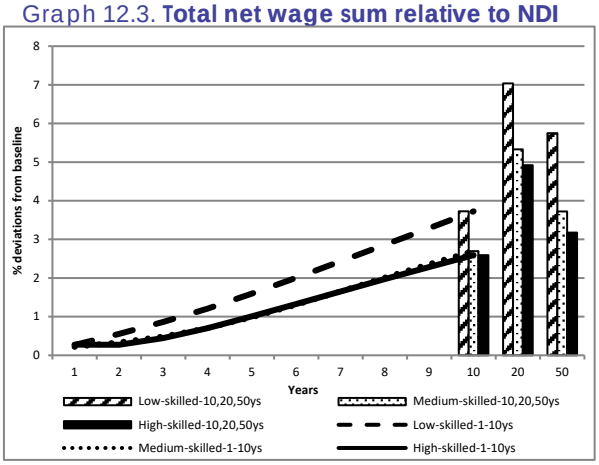
Graph 12.1. **Change in income shares (% of NDI)**



Graph 12.2. **Total net wage sum**

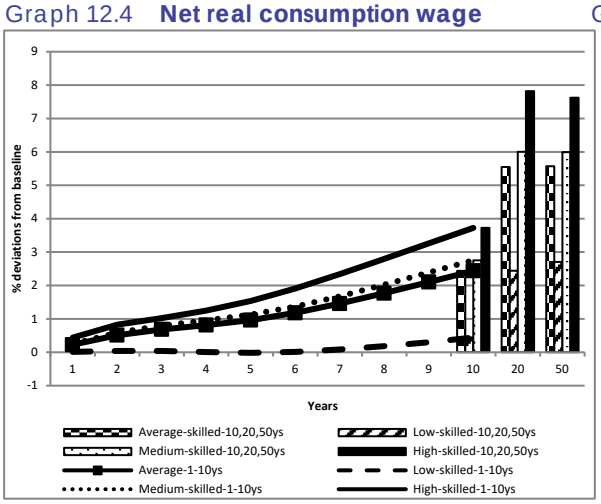


Graph 12.3. **Total net wage sum relative to NDI**

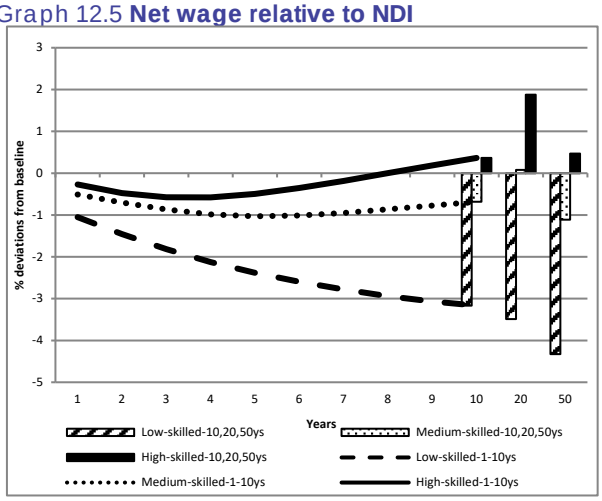


[8] We report here the standard scenarios, not the combination with product market reforms allowing for firm entry.

Graph 12.4 **Net real consumption wage**



Graph 12.5 **Net wage relative to NDI**

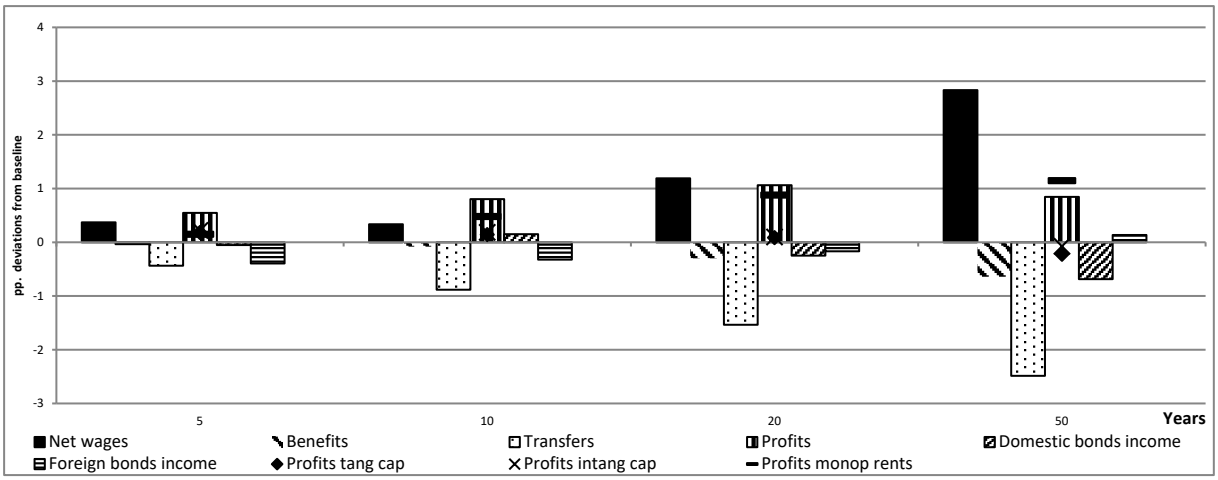


Note: The first graph shows the change of income shares in pp. deviation, the second and third graphs shows the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

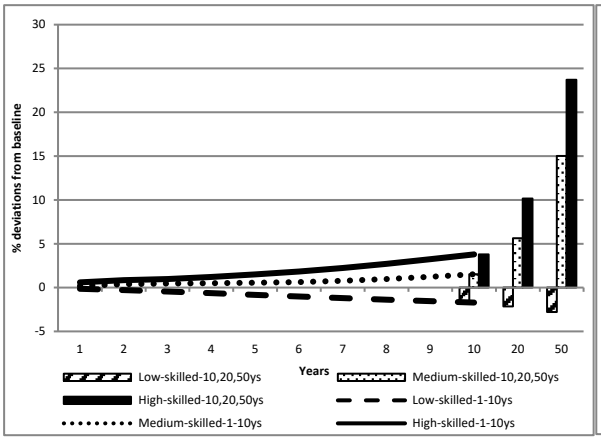
Source: Commission services

Graph 13. **Labour market reforms (skill-focussed)**

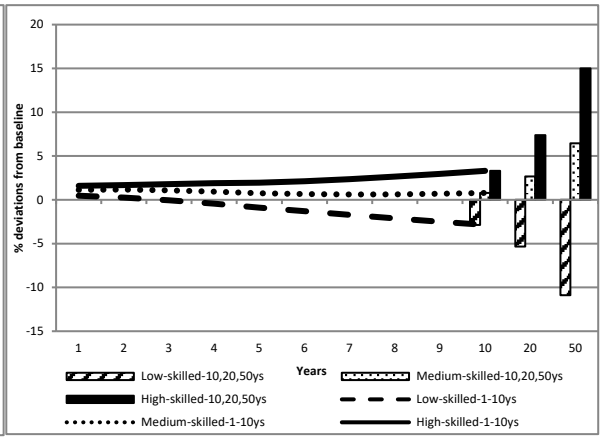
Graph 13.1. **Change in income shares (% of NDI)**



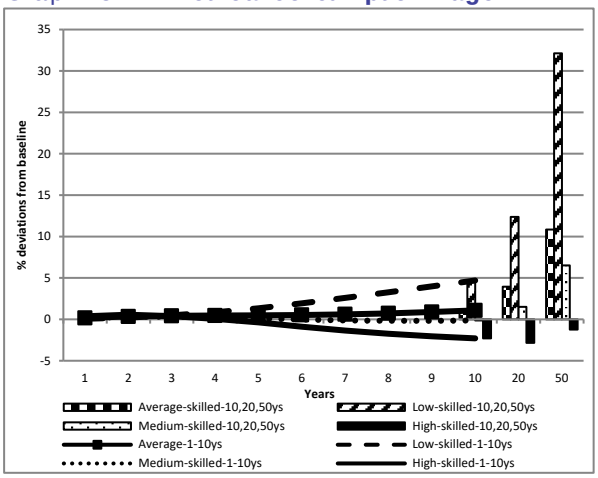
Graph 13.2 **Total net wage sum**



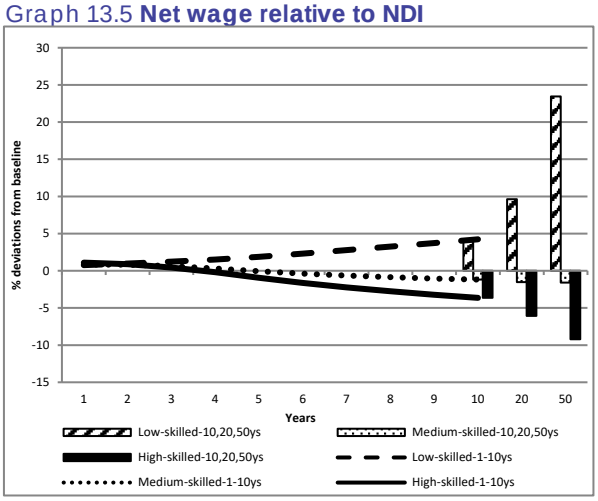
Graph 13.3 **Total net wage sum relative to NDI**



Graph 13.4. **Net real consumption wage**



Graph 13.5 **Net wage relative to NDI**



Note: The first graph shows the change of income shares in pp. deviation, the second and third graphs shows the deviation of total net wages alone and in % of net disposable income respectively (GDP deflated). The fourth graph shows the consumption price deflated net wages while the last graph presents the GDP deflated net wages relative to net disposable income. Deviations from baselines.

Source: Commission services

5. CONCLUSIONS

The focus in this paper was the distributional impacts of a comprehensive set of structural reforms, using an endogenous growth model calibrated on each EU member state. Our analysis is based on previous research that traces income gaps to differences in structural indicators across EU Member States and identifies reforms, which close the income gap by 50% in the long run. This analysis provides realistic quantitative measures for the order of magnitude of reforms needed to significantly close the income gap towards best performing countries in the EU. The set of reforms is comprehensive and ranges from goods market reforms (reducing service sector mark ups, reducing entry barriers) to a broad set of labour market reforms. The labour market reforms include reforms which aim at increasing the employment rate of low-skilled workers, increasing female labour force participation and those of the 55-64 age group, and benefit reductions, as well as reforms which aim at raising the skill level of the labour force (increasing the share of high- and medium-skilled workers via spending on education, and innovation subsidies).

Our analysis shows how general labour market reforms generate a trade-off between higher employment and lower wages in the short run. In the case of skill-specific labour market reforms, there is also a trade-off between an increase in employment of a particular group and the income of the average group member compared to income per capita. In general reforms which aim at increasing the employment rate of low-skilled workers are associated with a fall in wages relative to income per capita. This effect can be decomposed into wage distribution effects across skill groups, but the overall increase in the supply of labour also affects the distribution between wage earners and other income categories, especially capital owners. Capital owners generally benefit from labour market reforms, not

only in the form of an absolute increase in capital income, but also in the form of an increasing share in total income. The reason why this is happening is a scale effect in combination with limited entry into the final goods production sector. The relative increase in the capital income share associated with labour market reforms can only be substantially reduced if we allow for entry in the goods market. This suggests that labour market reforms combined with existing goods market rigidities can lead to suboptimal distributional effects. The result echoes the finding in Blanchard and Giavazzi (2003) that labour market reform without product market reform, which lowers the bargaining power of workers, redistributes product market rents from labour to capital without lowering the total size of the rents.

Labour market reforms that raise human capital, reduce the wage gap between low- and medium/high-skilled workers. Increasing the share of medium-skilled workers has a particularly strong positive effect on the wage of low-skilled workers. However, a distributional conflict arises between wage earners and transfer recipients. In the scenarios presented above, it has been assumed that transfer income is indexed (only) to inflation. Reforms which also increase productivity, therefore, increase the gap between wage and transfer income earners. The results for capital income are similar for labour market reforms that focus on increasing the participation rate and reforms that focus on increasing skills, with a relative increase in the capital income share and, thus, a potentially suboptimal distributional outcome, if entry in the goods market remains restricted.

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APPENDIX A: THE MODEL

The model economy is populated by households, final and intermediate goods producing firms, a research industry, a monetary and a fiscal authority. In the final goods sector firms produce differentiated goods which are imperfect substitutes for goods produced abroad. Final good producers use a composite of intermediate goods and three types of labour - low-, medium-, and high-skilled. Non-liquidity constrained households buy the patents of designs produced by the R&D sector and license them to the intermediate goods producing firms. The intermediate sector is composed of monopolistically competitive firms which produce intermediate products from rented capital input using the designs licensed from the household sector. The production of new designs takes place in research labs, employing high skilled labour and making use of the commonly available domestic and foreign stock of knowledge. Technological change is modelled as increasing product variety following Jones (1995, 2005) semi-endogenous growth framework with endogenous R&D.

Households

The household sector consists of a continuum of households $h \in [0,1]$. A share $(1-\varepsilon)$ of these households is not liquidity constrained and indexed by $i \in [0, 1-\varepsilon]$. They have access to financial markets where they can buy and sell domestic assets (government bonds), accumulate physical capital which they rent out to the intermediate sector, and they also buy the patents of designs produced by the R&D sector and license them to the intermediate goods producing firms. The remaining share ε of households is liquidity constrained and indexed by $k \in (1-\varepsilon, 1]$. These households cannot trade in financial and physical assets and consume their disposable income each period. For each skill group we assume that households (liquidity and non-liquidity constrained) supply differentiated labour services to unions which act as wage setters in monopolistically competitive labour markets. The unions pool wage income and distribute it in equal proportions among their members. Nominal rigidity in wage setting is introduced by assuming that the households face adjustment costs for changing wages.

Non-liquidity constrained households

Non-liquidity constrained households maximise an intertemporal utility function in consumption and leisure subject to a budget constraint. These households make decisions about consumption ($C_{i,t}$), and labour supply ($L_{i,s,t}$), the purchases of investment good ($J_{i,t}$) and government bonds ($B_{i,t}$), the renting of physical capital stock ($K_{i,t}$), the purchases of new patents from the R&D sector ($J_{A,i,t}$), and the licensing of existing patents ($A_{i,t}$), and receive wage income ($W_{s,t}$), unemployment benefits ($bW_{s,t}$), transfer income from the government ($TR_{i,t}$), and interest income (i_t, $i_{K,t}$ and $i_{A,t}$). Hence, non-liquidity constrained households face the following Lagrangian

$$\max_{\substack{\{C_{i,t}, L_{i,s,t}, B_{i,t} \\ J_{i,t}, K_{i,t} \\ J_{A,i,t}, A_{i,t}\}_{t=0}^{\infty}}} V_{i,0} = E_0 \sum_{t=0}^{\infty} \beta^t \left(U(C_{i,t}) + \sum_{s \in \{L,M,H\}} V(1 - L_{i,s,t}) \right)$$

$$- E_0 \sum_{t=0}^{\infty} \lambda_{i,t} \frac{\beta^t}{P_t} \begin{pmatrix} (1+t_{C,t}) P_{C,t} C_{i,t} + B_{i,t} + P_{I,t}\left(J_{i,t} + \Gamma_J(J_{i,t})\right) + P_{A,t} J_{A,i,t} \\ -(1+i_{t-1}) B_{i,t-1} \\ -\sum_s (1 - t_{w,s,t}) W_{s,t} L_{i,s,t} - bW_{s,t}(1 - NPART_{i,s,t} - L_{i,s,t}) \\ -(1-t_K)(i_{K,t-1} - rp_K) P_{I,t-1} K_{i,t-1} - t_K \delta_K P_{I,t-1} K_{i,t-1} - \tau_K P_{I,t} J_{i,t} \\ -(1-t_K)(i_{A,t-1} - rp_A) P_{A,t-1} A_{i,t-1} - t_K \delta_A P_{A,t-1} A_{i,t-1} - \tau_A P_{A,t} J_{A,i,t} \\ -TR_{i,t} - \int_0^N PR_{fin,j,i,t}\, dj - \int_0^{A_t} PR_{\text{int},m,i,t}\, dm \end{pmatrix} \quad \text{(A1)}$$

$$- E_0 \sum_{t=0}^{\infty} \lambda_{i,t} \xi_{i,t} \beta^t \left(K_{i,t} - J_{i,t} - (1-\delta_K) K_{i,t-1} \right) - E_0 \sum_{t=0}^{\infty} \lambda_{i,t} \psi_{i,t} \beta^t \left(A_{i,t} - J_{A,i,t} - (1-\delta_A) A_{i,t-1} \right)$$

where s is the index for the corresponding low- (L), medium- (M) and high-skilled (H) labour type respectively ($s \in \{L,M,H\}$). The budget constraints are written in real terms with the price for consumption, investment and patents ($P_{C,t}$, $P_{I,t}$, $P_{A,t}$) and wages ($W_{S,t}$) divided by GDP deflator (P_t). All firms of the economy are owned by non-liquidity constrained households who share the total profit of the final and intermediate sector firms, $\int_0^N PR_{fin,j,i,t}\, dj$ and $\int_0^{A_t} PR_{int,m,i,t}\, dm$, where N and A_t denote the number of firms in the final and intermediate sector respectively. As shown by the budget constraints, all households pay consumption taxes ($t_{C,t}$), wage income taxes ($t_{w,s,t}$) and t_K capital income taxes less tax credits (τ_K and τ_A) and depreciation allowances ($\tau_K \delta_K$ and $\tau_A \delta_A$) after their earnings on physical capital and patents. When investing into tangible and intangible capital the

household requires premium rp_K and rp_A in order to cover the increased risk on the return related to these assets. Households also receive unemployment benefits which are indexed to wages ($bW_{s,t}$). $NPART_{i,s,t}$ stands for the share of non-participants (inactives) and 1- $NPART_{i,s,t}$.- $L_{i,s,t}$ is the number of unemployed per skill group.

The utility function is additively separable in consumption ($C_{i,t}$) and leisure ($1\text{-}L_{i,s,t}$). We assume log-utility for consumption and allow for habit persistence.

$$U(C_{i,t}) = (1-habc)\log\left(C_{i,t} - habcC_{t-1}\right) \tag{A2}$$

We assume CES preferences with common elasticity but a skill specific weight (ω_s) on leisure. This is necessary in order to capture differences in employment levels across skill groups. Thus preferences for leisure are given by

$$V(1-L_{i,s,t}) = \frac{\omega_s}{1-\kappa}(1-L_{i,s,t})^{1-\kappa}, \tag{A3}$$

With $\kappa>0$. The investment decisions w.r.t. real capital are subject to convex adjustment costs, which are given by

$$\Gamma_J(J_{i,t}) = \frac{\gamma_K}{2}\frac{\left(J_{i,t}\right)^2}{K_{i,t-1}} + \frac{\gamma_I}{2}(\Delta J_{i,t})^2. \tag{A4}$$

The first order conditions of the household with respect to consumption, financial and real assets are given by the following equations:

$$\frac{\partial V_0}{\partial C_{i,t}} => U_{C,i,t} - \lambda_{i,t}(1+t_{C,t})\frac{P_{C,t}}{P_t} = 0 \tag{A5a}$$

$$\frac{\partial V_0}{\partial B_{i,t}} => -\lambda_{i,t} + E_t\left(\lambda_{i,t+1}\beta(1+i_t)\frac{P_t}{P_{t+1}}\right) = 0 \tag{A5b}$$

$$\frac{\partial V_0}{\partial K_{i,t}} => E_t\left(\lambda_{i.t+1}\frac{\beta P_{I,t}}{P_{t+1}}\left((1-t_K)(i_{K,t}-rp_K)+t_K\delta_K\right)\right) - \lambda_{i,t}\xi_{i,t} + E_t\left(\lambda_{i,t+1}\xi_{i,t+1}\beta(1-\delta_K)\right) = 0 \tag{A5c}$$

$$\frac{\partial V_0}{\partial J_{i,t}} => -\left(\left(1+\gamma_K\left(\frac{J_{i,t}}{K_{i,t-1}}\right)+\gamma_I\Delta J_{i,t}\right)-\tau_K\right) + E_t\left(\frac{1}{1+i_t}\frac{P_{I,t+1}}{P_{I,t}}\gamma_I\Delta J_{i,t+1}\right) + \xi_{i,t}\frac{P_t}{P_{I,t}} = 0. \tag{A5d}$$

Non-liquidity constrained households buy new patents of designs produced by the R&D sector ($I_{A,t}$) and rent their total stock of design (A_t) at rental rate $i_{A,t}$ to intermediate goods producers in period t. Households pay income tax at rate t_K on the period return of intangibles and they receive tax subsidies at rate τ_A. Hence, the first order conditions with respect to R&D investments are given by

$$\frac{\partial V_0}{\partial A_{i,t}} => E_t\left(\lambda_{i.t+1}\frac{\beta P_{A,t}}{P_{t+1}}\left((1-t_K)(i_{A,t}-rp_A)+t_K\delta_A\right)\right) - \lambda_{i,t}\psi_{i,t} + E_t\left(\lambda_{i,t+1}\psi_{i,t+1}\beta(1-\delta_A)\right) = 0 \tag{A6a}$$

$$\frac{\partial V_0}{\partial J_{A,i,t}} => -\frac{P_{A,t}}{P_t}(1-\tau_A) + \psi_{i,t} = 0\,\cdot \tag{A6b}$$

Therefore, the rental rate can be obtained from (6a), (6b) and (5b):

$$i_{A,t} = E_t\left(\frac{(1-\tau_A)(i_t - \pi_{A,t+1} + \delta_A + \delta_A\pi_{A,t+1}) - t_K\delta_A}{1-t_K}\right) + rp_A \tag{A6c}$$

where $1+\pi_{A,t+1} = \frac{P_{A,t+1}}{P_{A,t}}$.

Equation (6c) states that households require a rate of return on intangible capital which is equal to the nominal interest rate minus the rate of change of the value of intangible assets and also covers the cost of economic depreciation plus a risk premium. Governments can affect investment decisions in intangible capital by giving tax incentives in the form of tax credits and depreciation allowances or by lowering the tax on the return from patents.

Liquidity constrained households

Liquidity constrained households do not optimise but simply consume their current income at each date. Real consumption of household k is thus determined by the net wage income plus benefits and net transfers:

$$(1+t_{C,t})P_{C,t}C_{k,t} = \sum_{s\in\{L,M,H\}}\left(\left(1-t_{w,s,t}\right)W_{s,t}L_{k,s,t} + bW_{s,t}(1-NPART_{k,s,t}-L_{k,s,t})\right) + TR_{k,t}. \tag{A7}$$

Wage setting

Within each skill group a variety of labour services are supplied which are imperfect substitutes to each other. Thus, trade unions can charge a wage mark-up ($1/\eta_{s,t}$) over the reservation wage. The reservation wage is given as the marginal utility of leisure divided by the corresponding marginal utility of consumption. The relevant net real wage to which the mark up adjusted reservation wage is equated is the gross wage adjusted for labour taxes, consumption taxes and unemployment benefits, which act as a subsidy to leisure. Thus, the wage equation is given as

$$\frac{U_{1-L,h,s,t}}{U_{C,h,s,t}}\frac{1}{\eta_{s,t}} = \frac{W_{s,t}(1-t_{w,s,t}-b)}{P_{C,t}(1+t_{C,t})} \text{ for } s \in \{L, M, H\}, \tag{A8}$$

where b is the benefit replacement rate.

Aggregation

The aggregate of any household specific variable $X_{h,t}$ in per capita terms is given by

$$X_t = \int_0^1 X_{h,t}dh = (1-\varepsilon)X_{i,t} + \varepsilon X_{k,t}. \tag{A9}$$

Hence, aggregate consumption and employment is given by

$$C_t = (1-\varepsilon)C_{i,t} + \varepsilon C_{k,t} \tag{A10}$$

and

$$L_t = (1-\varepsilon)L_{i,t} + \varepsilon L_{k,t}. \tag{A11}$$

Firms

Final output producers

Since each firm produces a variety of the domestic good which is an imperfect substitute for the varieties produced by other firms, it acts as a monopolistic competitor facing a demand function with a price elasticity given by σ_d. Final output (Y_t) is produced using A_t varieties of intermediate inputs ($x_{m,t}$) with an elasticity of substitution $1/(1-\theta) > 1$. The final good sector uses labour aggregate ($L_{Y,t}$) and intermediate goods in a Cobb-Douglas technology, subject to overhead labour FC_L and fixed costs FC_Y

$$Y_t = (L_{Y,t})^{\alpha}\left(\int_0^{A_t}(x_{m,t})^{\theta}dm\right)^{\frac{1-\alpha}{\theta}} KG_t{}^{\alpha_G} - FC_Y \tag{A12}$$

with

$$L_{Y,t} = \left(\Lambda_L{}^{\frac{1}{\mu}}(\chi_L L_{L,t})^{\frac{\mu-1}{\mu}} + \Lambda_M{}^{\frac{1}{\mu}}\left(\chi_M(L_{M,t}-FC_L)\right)^{\frac{\mu-1}{\mu}} + \Lambda_{HY}{}^{\frac{1}{\mu}}(\chi_{HY}L_{HY,t})^{\frac{\mu-1}{\mu}}\right)^{\frac{\mu}{\mu-1}} \tag{A13}$$

$L_{L,t}$, $L_{M,t}$ and $L_{HY,t}$ denote the employment of low, medium and high-skilled in final goods production respectively. Parameter Λ_z is the corresponding share parameter $(z \in \{L, M, HY\})$, χ_z is the efficiency unit, and μ is the elasticity of substitution between different labour types. Note that high-skilled workers can work in the final goods and the R&D sector as well, therefore the total number of high-skilled ($L_{H,t}$) should be equal to the number of high-skilled employed in the final goods ($L_{HY,t}$) and in the R&D sector respectively ($L_{RD,t}$):

$$L_{H,t} = L_{HY,t} + L_{RD,t}. \tag{A14}$$

We account for the productivity-enhancing effects of infrastructure investment via a production function where the public capital stock ($K_{G,t}$) enters externally.

In a symmetric equilibrium, the demand for labour and intermediate inputs is given by

$$\alpha\frac{Y_t+FC_Y}{L_{Y,t}}\left(\frac{L_{Y,t}}{L_{z,t}}\right)^{\frac{1}{\mu}}\Lambda_z{}^{\frac{1}{\mu}}(\chi_L)^{\frac{\mu-1}{\mu}}\eta = W_{z,t}, z \in \{L, HY\} \tag{A15a}$$

$$\alpha\frac{Y_t+FC_Y}{L_{Y,t}}\left(\frac{L_{Y,t}}{L_{M,t}-FC_L}\right)^{\frac{1}{\mu}}\Lambda_M{}^{\frac{1}{\mu}}(\chi_M)^{\frac{\mu-1}{\mu}}\eta = W_{M,t} \tag{A15b}$$

$$px_{m,t} = \eta(1-\alpha)(Y_t + FC_Y)\left(\int_0^{A_t}(x_{m,t})^{\theta}dm\right)^{-1}(x_{m,t})^{\theta-1} \tag{A16}$$

where $\eta = 1 - 1/\sigma_d$ and $px_{m,t}$ is the price of intermediate goods.[9]

Intermediate goods producers

The intermediate sector consists of monopolistically competitive firms which have entered the market by licensing a design from domestic households and by making an initial payment FC_A to overcome administrative entry barriers. Capital inputs are also rented from the household sector for a rental rate of $i_{K,t}$. Firms which have acquired a design can transform each unit of capital into a single unit of an intermediate input. In a symmetric equilibrium, the respective inverse demand functions of intermediate goods producing firms are given as (A16), therefore the first order condition is

$$\theta\eta(1-\alpha)(Y_t + FC_Y)\left(\int_0^{A_t}(x_{m,t})^{\theta}dm\right)^{-1}(x_{m,t})^{\theta-1} = i_{K,t}. \quad \text{(A17)}$$

Intermediate goods producers set prices with a mark-up over marginal cost. Therefore intermediate goods prices are given by:

$$px_{m,t} = \frac{i_{K,t}}{\theta}. \quad \text{(A18)}$$

The no-arbitrage condition requires that entry into the intermediate goods producing sector takes place until

$$PR_{\text{int},m,t} = i_{A,t}P_{A,t} + \left(i_{A,t} + \pi_{A,t+1}\right)FC_A, \quad \forall m. \quad \text{(A19)}$$

For an intermediate producer, entry costs consist of the licensing fee $i_{A,t}P_{A,t}$ for the design or patent which is a prerequisite of production of innovative intermediate goods and a fixed administrative entry cost FC_A.

R&D sector

Innovation corresponds to the discovery of a new variety of producer durables that provides an alternative way of producing the final good. The R&D sector hires high-skilled labour ($L_{RD,t}$) and generates new designs according to the following knowledge production function:

$$\Delta A_t = \nu A_{t-1}^{*\,\omega} A_{t-1}^{\varphi}\left(L_{RD,t}\right)^{\lambda}. \quad \text{(A20)}$$

In this framework we allow for international R&D spillovers following Bottazzi & Peri (2007). Parameters ω and φ measure the foreign and domestic spillover effects from the aggregate international and domestic stock of knowledge (A^*_t and A_t) respectively. Negative value for these parameters can be interpreted as the "fishing out" effect, i.e. when innovation decreases with the level of knowledge, while positive values refer to the "standing on shoulders" effect and imply positive research spillovers. Note that φ=1 would yield the strong scale effect feature of endogenous growth models with respect to the domestic level of knowledge. Parameter ν can be interpreted as total factor efficiency of R&D production, while λ measures the elasticity of R&D production on the number of researchers ($L_{RD,t}$). The international stock of knowledge grows exogenously at rate g_{A^*}. We assume that the R&D sector is operated by a research institute which employs high skilled labour at their market wage, $W_{H,t}$. We also assume that the research institute faces an adjustment cost (γ_A) of hiring new employees and maximises the following discounted profit-stream:

$$\max_{L_{RD,t}} \sum_{t=0}^{\infty} d_t\left(P_{A,t}\Delta A_t - W_{H,t}L_{RD,t} - \frac{\gamma_A}{2}W_{H,t}\left(\Delta L_{RD,t}\right)^2\right) \quad \text{(A21)}$$

where d_t is the discount factor. High-skilled are paid the same wages across sectors: $W_{H,t}=W_{HY,t}$.

Policy

On the expenditure side we distinguish between government consumption (G_t), government investment (IG_t), government transfers (TR_t) and unemployment benefits (BEN_t), where:

$$BEN_t = \sum_{s\in\{L,M,H\}} bW_{s,t}(1 - NPART_{s,t} - L_{s,t}), \quad \text{(A22)}$$

where b is the benefit replacement rate.

The government provides subsidies (SUB_t) on physical capital and R&D investments in the form of a tax-credit and depreciation allowances:

$$SUB_t = t_K\left(\delta_K P_{I,t-1}K_{i,t-1} + \delta_A P_{A,t-1}A_{i,t-1}\right) + \tau_K P_{I,t}J_{i,t} + \tau_A P_{A.t}J_{A,i,t}. \quad \text{(A23)}$$

[9] Note that η is inversely related to the net mark-ups in the final goods sector (mkp_f): $\eta = 1/(1+ mkp_f)$.

Government revenues R_t^G are made up of taxes on consumption as well as capital and labour income. Government debt (B_t) evolves according to

$$B_t = (1+i_t)B_{t-1} + G_t + IG_t + TR_t + BEN_t + SUB_t - R_t^G. \quad \text{(A24)}$$

The labour tax ($t_{w,t}$) used for controlling the debt to GDP ratio according to the following rule:

$$\Delta t_{w,t} = \tau_B \left(\frac{B_{t-1}}{Y_{t-1}} - b^T \right) + \tau_{DEF} \Delta \left(\frac{B_t}{Y_t} \right), \quad \text{(A25)}$$

where τ_B captures the sensitivity with respect to deviations from b^T, the government debt target and τ_{DEF} controls the sensitivity of the tax-rule w.r.t. changes in the debt to output ratio.

Monetary policy is modelled via the following Taylor rule, which allows for some smoothness of the interest rate response (i_t) to the inflation and output gap:

$$i_t = \gamma_{ilag} i_{t-1} + (1-\gamma_{ilag})\left(r_{EQ} + \pi_{TAR} + \gamma_{\inf}\left(\pi_{C,t} - \pi_{TAR}\right) + \gamma_{ygap}\tilde{y}_t\right). \quad \text{(A26)}$$

The central bank has a constant inflation target (π_{TAR}) and it adjusts interest rates whenever actual consumer price inflation ($\pi_{C,t}$) deviates from the target and it also responds to the output gap $(\tilde{y}_t)$ via the corresponding $\gamma_{\inf}$ and γ_{ygap} coefficients. There is also some inertia in nominal interest rate setting over the equilibrium real interest rate r_{EQ} determined by γ_{ilag}. Output gap is defined as deviation of capital and labour utilisation from their long run trends. Note that in our multicountry setting, members of the euro area do not have independent monetary policy, we assume that the European Central Bank sets interest rate by taking into account the euro area wide aggregate inflation and output gap changes in its Taylor-rule.

Trade

In order to facilitate aggregation we assume that households, the government and the final goods sector have identical preferences across goods used for private consumption, investment and public expenditure. Let $Z_t \in \{C_t, I_t, G_t, IG_t\}$ be the demand of households, investors or the government as defined in the previous section, then their preferences are given by the following utility function:

$$Z_t = \left((1-\rho)^{\frac{1}{\sigma_{im}}} Z_{d,t}^{\frac{\sigma_{im}-1}{\sigma_{im}}} + \rho^{\frac{1}{\sigma_{im}}} Z_{f,t}^{\frac{\sigma_{im}-1}{\sigma_{im}}} \right)^{\frac{\sigma_{im}}{\sigma_{im}-1}}. \quad \text{(A27)}$$

where ρ is the share parameter and σ_{im} is the elasticity of substitution between domestic ($Z_{d,t}$) and foreign produced goods ($Z_{m,t}$).

Calibration

We calibrate our model in a multicountry setting for each Member States and the rest of the world. We select behavioural and technological parameters for the individual countries such that the model can replicate important empirical ratios such as labour productivity, investment, consumption to GDP ratios, the wage share, the employment rate and the R&D share, given a set of structural indicators describing market frictions in goods and labour markets, tax wedges and skill endowments. Most of the variables and parameters are taken from available statistical or empirical sources from the literature and the remaining parameters are tied down by the mathematical relationship of the model-equations.

Goods Market:

We identify the intermediate sector as the investment goods' sector (mostly R&D intensive subsectors of manufacturing) and the final goods sector as the aggregate of all remaining market sectors. The investment goods' sector resembles the intermediate sector along various dimensions. First, this sector is more R&D and patent intensive, second, a large fraction of these manufacturing sectors supply innovative goods (in the form of invest-ment goods but also innovative consumer goods). Final goods sectors, including services, on the other hand are typically not subject to large (patented) innovations but rely on organisational changes possibly in relation to new technologies supplied by the investment goods'sector sector. Also the two sectors differ in the degree of competition, with manufacturing showing smaller mark ups compared to final goods sectors. Our calibration of mark ups is based on Roeger (1995) and Canton and Thum-Thysen (2015). Using the most recent EU KLEMS databank the average mark-up for manufacturing is 10%, while for final goods/service sector it is around 17% in the Euro Area. Concerning entry barriers we rely on estimates provided by the Doing Business Database.

Knowledge production technology:
Empirical evidence on output elasticities has been provided by Bottazzi and Peri (2007) and Pessoa (2005). The growth rate of ideas was obtained from Pessoa (2005) with the assumption of a 5% obsolescence rate. In our model the R&D elasticity of research labour (λ) is determined by the wage cost share in the total R&D spending. We rely on Bottazzi and Peri (2007) to calibrate the knowledge elasticity parameters w. r. t. domestic and foreign knowledge capital. The authors do not estimate directly φ and ω, only the ratio between these coefficients and λ. These estimates together with the long-run growth rate of intangible capital (from equation A20) and λ pin down the corresponding elasticities.
Labour market and the skill composition of the labour force:
We rely on Ratto et al. (2009) to calibrate the adjustment parameters of the labour market. Labour force is disaggregated into three skill-groups: low-, medium- and high-skilled labour. We define high skilled workers as that segment of labour force that can potentially be employed in the R&D sector, i.e. engineers and natural scientists. Our definition of low-skilled corresponds to the standard classification of ISCED 0-2 education levels and the rest of the labour force is considered as medium-skilled. Data on skill-specific population shares, participation rates and wages are obtained from the Labour Force Survey, SES, and the Science and Technology databases of EUROSTAT. The elasticity of substitution between different labour types (μ) is one of the major parameters addressed in the labour-economics literature. We rely on Acemoglu and Autor (2011) which updated the seminal reference for this elasticity parameter by Katz and Murphy (1992, "KM" hereafter). While KM estimated that the elasticity of substitution between skilled and unskilled labour is about 1.4, Acemoglu and Autor (2011) argues for somewhat higher estimates in the range of 1.6-1.8 on the extended data sample of KM (from 1963 to 2008 as opposed to 1968-1987). We take 1.7 as our baseline value. The efficiency units are restricted by the labour demand equations which imply the following relationship between wages, skill-specific population and employment ratios, and efficiency units. In our baseline calibration low-skilled wages are obtained from the annual earnings of employees with low educational attainment (ISCED 0-2) irrespective of their occupation. High-skilled wages are approximated by the annual earnings of scientists and engineers with tertiary educational attainment employed as professionals or associate professionals in physical, mathematical, engineering, life science or health occupations (ISCO-08 occupations 21, 22, 31, 32). Earnings data of employees with tertiary educational attainment not working as scientists and engineers and employees with medium educational attainment (ISCED 3-4) irrespective of their occupation are taken to calculate wages for our medium-skilled in the model.

Fiscal, monetary and trade variables:
We use EUROSTAT for the breakdown of government spending into consumption, investment and transfers and we use effective tax rates on labour, capital and consumption to determine government revenues. In addition we use estimates of R&D tax credits from OECD (2015c). Monetary policy parameters are adopted from Ratto et al. (2009) while the bilateral trade data is obtained from the EUROSTAT/COMEXT database.

APPENDIX B: STRUCTURAL REFORM SCENARIOS

Varga and in 't Veld (2014) applies a benchmarking methodology to quantify the magnitude of structural reforms and assesses their economic effects through model-based simulations. The simulated shocks are based on a set of structural reform indicators covering a broad set of areas, including market competition and regulation, tax-structure and a wide range of labour market reforms. Labour market reforms included reforms which aim at increasing the employment of low skilled workers, increasing female and elderly labour force participation, and reforms which aim at raising the skill level of the labour force through increasing the share of high and medium skilled workers and innovation subsidies (i.e. labour market reforms "2.0"). Table A.1. below shows the corresponding indicators for each of these reform fields, the targeted benchmark values and the relative position of the Member States with respect to the benchmarks. The benchmarks are defined as the average of the indicators in the three best-performing EU countries except for unemployment benefit replacement rate where the EU average was set as target. Varga and in 't Veld (2014) defines the potential for reform as closing by one-half of the gap in these indicators vis-à-vis the benchmarks. To allow for realistic implementation lags, the authors phase in the reforms gradually. Changes in mark-ups are introduced with a speed of at most one percentage point (pp) per year, tax reforms are phased in over a five-year period, while education and pension reforms are introduced over a 25-year period in order to account for the cohort effects. For more details, see Varga and in 't Veld (2014).

Table 1. Structural indicators and benchmarks

		AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	Average 3 best EU performers
Market competition	Services sector markups (%)	14.3	14.5	10.7	12.2	15.8	13.9	11.6	15.5	18.6	14.5	15.7	14.3	n.a.	14.5	12.9	12.8	16.6	17.0	18.0	9.5	12.4	14.2	14.6	19.6	12.3	14.2	16.0	11.5	10.6
Market regulation	Entry costs (%)	6.3	6.0	5.4	14.4	10.0	4.8	1.1	2.2	5.8	9.0	4.9	1.9	6.4	8.4	1.6	15.3	1.5	4.6	3.0	17.9	5.7	19.6	2.8	4.1	2.5	1.6	4.5	1.3	1.3
Tax reform	Labour to consumption tax revenue ratio	2.4	3.0	0.7	1.1	1.7	2.5	1.9	1.3	1.7	2.6	2.0	2.8	1.0	1.4	1.6	3.0	1.4	1.9	1.4	1.2	2.6	1.5	1.3	1.0	1.9	1.7	1.7	1.5	0.9
Labour market reforms 1.0	Female non-participation (%, 25-55ys):																													
	- low-skilled	31.8	44.3	49.5	29.2	38.8	38.8	39.2	34.8	36.5	27.9	44.2	36.4	37.9	37.5	57.0	50.8	37.6	29.5	35.4	56.1	37.2	49.6	22.4	47.7	32.1	27.3	38.8	40.5	25.9
	- medium-skilled	13.9	19.6	18.1	20.4	17.2	16.2	13.9	17.4	27.8	17.8	17.6	15.3	22.9	20.6	31.2	27.7	14.9	22.5	17.3	21.7	15.4	24.8	8.7	27.6	11.6	11.4	18.9	19.8	11.0
	- high-skilled	10.4	8.9	9.2	9.4	19.8	11.3	9.0	12.7	10.6	10.1	10.8	9.4	6.7	15.6	15.3	18.3	5.9	11.9	9.6	7.2	8.3	8.7	5.8	7.8	6.8	6.1	19.4	12.1	5.9
	Low-skilled male non-participation (%, 25-55ys)	20.9	21.2	33.7	16.0	25.8	17.0	21.1	22.0	8.5	9.8	24.7	15.3	24.9	21.4	22.0	16.3	30.2	10.0	19.6	6.3	16.3	28.4	10.4	15.8	15.1	16.4	25.6	18.4	8.2
	Elderly non-participation (%, 55-64ys):																													
	- low-skilled	22.7	25.4	17.6	18.6	28.0	12.7	14.7	12.6	21.2	14.7	21.2	22.3	30.9	23.5	19.2	19.1	12.9	19.8	11.8	21.6	17.1	29.9	15.4	20.8	11.9	31.0	27.6	14.3	12.1
	- medium-skilled	12.0	10.9	10.4	8.3	10.2	8.0	7.7	9.2	11.3	6.0	9.4	11.2	13.2	12.9	6.7	7.2	10.9	15.1	10.1	6.8	6.7	15.8	4.1	13.4	4.7	15.9	11.3	7.1	5.0
	- high-skilled	5.0	6.0	5.8	4.1	3.0	4.4	4.0	3.8	8.0	3.8	5.3	5.2	5.9	6.6	3.8	3.3	3.7	4.9	4.1	4.0	3.5	4.1	4.0	5.1	2.3	6.4	4.2	5.4	2.9
	Benefit replacement rate* (%)	69.3	63.8	37.4	n.a.	57.0	60.8	71.5	45.8	17.0	43.7	73.0	59.0	n.a.	28.5	74.0	9.3	37.8	72.9	47.7	54.9	69.6	47.7	48.3	25.3	62.7	60.2	45.9	61.2	51.4
Labour market reforms 2.0	Share of high-skilled (%)	6.2	7.9	6.5	9.0	6.1	9.1	7.3	11.0	7.2	10.2	12.3	8.0	4.9	5.0	9.3	4.2	10.0	7.8	7.4	3.2	6.3	6.0	4.0	5.0	8.8	6.7	5.2	7.0	11.2
	Expenditure on high-skilled education (% GDP)	0.4	1.3	0.2	0.4	0.3	0.4	0.5	0.3	0.4	0.3	0.7	0.3	0.2	0.2	0.4	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.2	0.5	0.4	0.2	0.3	0.5
	Share of low-skilled (%)	15.4	25.3	18.1	22.1	6.8	13.2	19.6	8.9	29.6	42.6	12.3	22.5	16.7	16.8	20.2	40.1	6.5	24.0	9.9	56.5	23.6	9.2	54.9	25.0	15.7	13.2	8.6	20.3	7.3
	Expenditure on medium-skilled education (% GDP)	3.8	3.0	2.1	4.8	2.8	3.3	4.8	3.1	3.2	2.6	4.3	3.5	1.6	2.8	3.5	2.6	3.4	2.6	2.6	6.1	3.9	2.6	3.0	1.7	3.9	3.1	2.5	3.5	2.9
	R&D tax-credit rates	0.15	0.11	n.a.	n.a.	0.18	-0.02	-0.01	n.a.	0.10	0.33	0.00	0.34	n.a.	0.18	0.26	0.09	n.a.	-0.01	n.a.	n.a.	0.21	0.05	0.33	n.a.	0.05	0.17	0.10	0.19	0.33

Notes: * for benefit replacement rate: EU average. Darker shades correspond to larger gap vis-à-vis the benchmark Sources: services mark-ups, 2013: based on Canton and Thum-Thysen (2015); entry costs: starting business costs in % of income per capita, 2016: Doing business database. www.doingbusiness.org; Tax revenues, 2014: European Commission, Taxation trends in the European Union, 2016 edition, Luxembourg, 2016.; Skill-shares, non-participation rates, 2015 or latest available: EUROSTAT, low-skilled correspond to ISCED 0-2 categories, high-skilled correspond to scientists and engineers (in natural science, mathematics, computing, manufacturing or construction), the rest of the population is defined as medium-skilled; Education expenditures: 2011 or latest available: EUROSTAT, corrected with the share of high and medium skilled shares; benefit replacement rates, 2014: OECD, Benefits and Wages Statistics. www.oecd.org/els/benefitsandwagesstatistics.htm; average of net replacement rates over 60 months of unemployment, 2016; R&D tax-credit rates: 2015 or latest available data, average over large and small firms OECD (2016), 2016 edition of R&D tax incentive indicators, OECD Publishing.

APPENDIX C: The wage response to general versus skill-specific labour market reforms

In a standard macro model (CRS) it is fairly well understood that a labour market reform leads to an increase in employment and a fall in wages in the short run but in the long run wages return to their pre reform baseline level while employment remains higher permanently. Thus, labour market reforms generate a trade-off between wages and employment in the short run but in the long run such a trade-off does not exist. For a skill specific labour market reform (reforms which increase the employment of low skilled workers for example) the trade-off between (skill specific) wages and employment exists both in the short and the long run.

This appendix shows both effects, using a Cobb Douglas production function for capital and a labour aggregate and a CES function for aggregating labour by skill.

1) Aggregate labour market reform

Technology

$$Y = UK^{1-\alpha}L^{\alpha}$$

$$\frac{\partial Y}{\partial K} = (1-\alpha)\frac{Y}{K} = (1-\alpha)\left(\frac{L}{K}\right)^{1-\alpha} U = r + d$$

$$\frac{\partial Y}{\partial L} = \alpha\frac{Y}{L} = \alpha\left(\frac{K}{L}\right)^{\alpha} U = W$$

The FOC for capital determines the capital labour ratio in the long run, since *r* and *d* are constant. This means a labour market reform which increases employment also leads to an increase in the capital stock until the initial capital output ratio is re-established. Since the post reform capital labour ratio is unchanged, the post reform marginal product of labour is also unchanged which supports an unchanged real wage.

2) Aggregate labour market reforms in the case of skill specific labour

Now we allow that output is produced with capital and different types of labour. And labour input is combined in a CES aggregator:

$Y = UK^{1-\alpha}LCES^{\alpha}$

where:

$$LCES = \left[\sum_i s_i^{\frac{1}{\sigma}} L_i^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

There is average CES wage index *WCES* defined via:

$$WCES * LCES = \sum_i W_i L_i$$

Now we get the following FOCs w. r. t. K and the labour aggregate LCES:

$$\frac{\partial Y}{\partial K} = (1-\alpha)\frac{Y}{K} = (1-\alpha)\left(\frac{LCES}{K}\right)^{1-\alpha} U = r + d$$

$$\frac{\partial Y}{\partial LCES} = \alpha \frac{Y}{LCES} = \alpha \left(\frac{K}{LCES}\right)^{\alpha} U = WCES$$

The same logic applies in the disaggregate labour case as long as we concentrate on variations of LCES only (or a proportional change of all Li). Again a general labour market reform leading to an increase in LCES would increase K proportionally because of unchanged capital cost. The increase in the capital stock would thus not affect the marginal product of aggregate labour and the CES wage aggregate would remain constant (note *WCES =CES (Wi)*) and the skill specific real wage rates W_ii would therefore also remain constant.

3) Skill specific labour market reform

Now consider the case that only labour supply of a specific skill group *i* is increased. What happens to the skill specific wage in the long run?

$$\frac{\partial Y}{\partial LCES}\frac{\partial LCES}{\partial L_i} = \alpha \frac{Y}{LCES} s_i^{\frac{1}{\sigma}} \left(\frac{LCES}{L_i}\right)^{\frac{1}{\sigma}} = WCES * s_i^{\frac{1}{\sigma}} \left(\frac{LCES}{L_i}\right)^{\frac{1}{\sigma}} = W_i$$

WCES remains constant as in the case before (because the *K/LCES*) ratio does not change. But the constancy of *WCES* (in the long run) generates a trade-off between the increase of the $\frac{L_i}{LCES}$ ratio and a fall in W_i. Also notice this trade-off is stronger if L_i is small relative to *LCES* (because *LCES* is also changed by an increase in L_i with a magnitude depending on the relative size of L_i). This fall in skill specific wages is due to a loss in labour efficiency associated with an increase of L_i as measured by a declining marginal productivity of L_i ($\frac{\partial^2 LCES}{\partial L_i^2} < 0$). The efficiency loss is inversely related to the elasticity of substitution (σ) and goes to zero as the elasticity of substitution goes to zero.

APPENDIX D: Relationship between household income (after taxes) and GDP

This appendix explores the relationship between household income (after taxes) and GDP. This is helpful for the interpretation of the results since macroeconomic theory is more explicit on how reforms affect the factor income share relative to GDP. That means we can express factor and profit income as function of GDP (and other variables). Expressing household income also as function of GDP (and other variables) helps us in understanding which factors are driving the change in household income shares.

Household income (after taxes, but including depreciation) is given by:

$$I_t^H = (1 + t_t^C)C_t + \Delta B_t + P_t^K J_t^K + (1 - \tau^A)P_t^A \Delta A_t = i_{t-1}B_{t-1} + (1 - t_t^W)W_t L_t^Y + (1 - t_t^W)W_t^H L_{At} + (1 - t_t^K)i_{t-1}^K P_t^K K_{t-1} + (1 - t_t^K)i_{t-1}^A P_t^A A_{t-1} + PR_t^Y + A_t PR_t^x + BEN_t + TR_t \quad (1)$$

We can express the factor income components and profits as functions of GDP by using the FOCs of the firm's profit maximisation problem.

The FOC of final goods producer *j* w. r. t. labour and intermediate capital input *i* is given by (we disregard scc):

$$\left(1 - mup_{jt}^Y\right)\alpha \frac{(Y_{jt} + FC_Y)P_t^Y}{L_{Yjt}} = W_t \quad (2a)$$

And one can express final goods sector wage income as:

$$\left(1 - mup_{jt}^Y\right)\alpha\left(Y_{jt} + FC_Y\right)P_t^Y = W_t L_{Yjt} \quad (2b)$$

The FOC w. r. t. intermediate capital good is given by:

$$\left(1 - mup_{jt}^Y\right)(1 - \alpha)\frac{(Y_{jt} + FC_Y)P_t^Y}{Ax_{ijt}^\theta} x_{ijt}^{\theta - 1} = \left(1 - mup_{jt}^Y\right)(1 - \alpha)\frac{(Y_{jt} + FC_Y)P_t^Y}{Ax_{ij}} = P_{it}^x \quad (3)$$

Profit of intermediate goods producer *i*:

$$PR_{it}^x = P_{it}^x x_{it} - i_t^K P_t^K x_{it} - i_t^A P_t^A \quad (4)$$

Notice, cost for intangible capital is sunk for the intermediate goods producer. The optimal pricing condition for intermediate producer is based on equating marginal revenue (taking into account the demand for intermediates from the final goods producer) and marginal cost.

Using (3) one can write the FOC for the intermediate goods producer as:

$$\frac{dPR_{it}^x}{dx_{it}} = \theta(1 - mup_t^Y)(1 - \alpha)\frac{(Y_t + FC_Y)P_t^Y}{Ax_{it}^\theta} x_{it}^{\theta - 1} - i_t^K P_t^K = 0 \quad (5a)$$

or:

$$P_{it}^x = \frac{i_t^K P_t^K}{\theta} \quad (5b)$$

From here onwards we assume symmetry across final goods firms and intermediate goods firms.

Using (3) one can express the rental income from physical capital as a function of GDP:

$$\theta(1-mup_t^Y)(1-\alpha)(Y_t+FC_Y)P_t^Y = i_t^K P_t^K A_t x_t \quad (6)$$

The household FOC w. r. t. to intangible capital is given by:

$$P_t^A = \frac{1}{1+i_t+rp_t^A}(P_t^x x_t - i_t^K P_t^K x_t + P_{t+1}^A) = \frac{1}{1+i_t+rp_t^A}(P_t^x x_t - i_t^K P_t^K x_t + P_t^A(1+\pi_{t+1}^A) \quad (7)$$

This can be written as

$$(i_t + rp_t^A - \pi_{t+1}^A)P_t^A = i_t^A P_t^A = (P_t^x x_t - \theta P_t^x x_t) = (1-\theta)P_t^x x_t \quad (8)$$

From which it follows that

$$PR_t^x = 0 \quad (9)$$

Thus free entry into the intermediate goods sector reduces profits to zero.

Rewriting the free entry condition, using (3) the rental income from intangible capital can be derived

$$i_t^A P_t^A = (1-\theta)(1-mup_t^Y)(1-\alpha)\frac{(Y_t+FC_Y)P_t^Y}{Ax_t}x_t \quad (10)$$

$$i_t^A P_t^A = (1-\theta)(1-mup_t^Y)(1-\alpha)\frac{(Y_t+FC_Y)P_t^Y}{A_t} \quad (11)$$

$$i_t^A P_t^A A_t = (1-\theta)(1-mup_t^Y)(1-\alpha)\big(Y_{jt}+FC_Y\big)P_t^Y \quad (12)$$

Making use of the FOCs, profit income in the final goods sector can be written as follows:

$$PR_t^Y = P_t^Y Y_y - W_t L_t^Y - i_t^K P_t^K K_t - i_{t-1}^A P_t^A A_t = mup_t^Y Y_t P_t^Y - (1-mup_t^Y)P_t^Y FC_Y \quad (13)$$

Now we can rewrite the sum of factor and profit income as follows:

$$\begin{aligned}(1-t_t^W)W_t L_t^Y + i_{t-1}^K P_t^K K_{t-1} + i_{t-1}^A P_t^A A_{t-1} + PR_t^Y + PR_t^x + W_t^H L_{At} \\ = \Big(\alpha + (1-\alpha)\big(\theta + (1-\theta)\big)\Big)(1-mup_t^Y)(Y_t+FC_Y)P_t^Y + mup_t^Y Y_t P_t^Y \\ - (1-mup_t^Y)P_t^Y FC_Y + W_t^H L_{At} + W_t^H L_{At} \\ = P_t^Y Y_{jt} + W_t^H L_{At} \\ = GDP_t^F\end{aligned} \quad (14)$$

where GDP at factor cost is:

$$GDP_t^F = P_t^Y Y_t + W_t^H L_{At}$$

We can rewrite the household income equation:

$$I_t^H = i_{t-1}B_{t-1} + GDP_t^F - t_t^W W_t L_{Yt} + t_t^W W_t^H L_{At} + t_t^K i_{t-1}^K P_t^K K_{t-1} + t_t^K i_{t-1}^A P_t^A A_{t-1} + BEN_t + TR_t \quad (1a)$$

The government budget constraint is:

$$\Delta B_t = i_t B_t + G_t + I_t^G + BEN_t + TR_t - t_t^W W_t L_{Yt} - t_t^W W_t^H L_{At} + t_t^K i_{t-1}^K P_t^K K_{t-1} + t_t^K i_{t-1}^A P_t^A A_{t-1} - t_t^C C_t \quad (15)$$

Now we can rewrite the relationship between household income and GDP as follows:

$$I_t^H = GDP_t^F + t_t^C C_t + \Delta B_t - G_t - I_t^G = GDP_t^M + \Delta B_t - G_t - I_t^G \quad (16)$$

where:

$$GDP_t^M = GDP_t^F + t_t^C C_t \quad (17)$$

is GDP at market prices.

Household income is lower than GDP because of government purchases and government investment, while an increase in government debt increases household income relative to GDP. This is intuitive because an increase I government debt means that the government is not financing all of its expenditures via taxes (which lowers household income). It is also intuitive why G and IG lower income relative to GDP, because of the tax financing needs. Notice, government spending on benefits and transfers does not affect the relationship between GDP and household income because the aggregate household sector receives transfers and benefits as income.

These relationships can be used to see how the share of gross wages in total household income is determined:

$$GWS = \frac{(1-mup_t^Y)\alpha(Y_t+FC_Y)P_t^Y + W_t^H L_{At}}{P_t^Y Y_t + W_t^H L_{At} + t_t^C C_t + \Delta B_t - G_t - I_t^G} = \frac{W_t L_{Yt} + W_t^H L_{At}}{P_t^Y Y_t + W_t^H L_{At} + t_t^C C_t + \Delta B_t - G_t - I_t^G} \quad (18)$$

Suppose a structural reform has positive GDP effects, and leaves the consumption, deficit, G_t and I_t^G share in GDP constant, then the (gross) wage share in income is declining, unless the mark up falls or fixed costs increase. The gross wage share in total income could also falls if mark ups and fixed costs are negligible and G_t and I_t^G increase less than GDP or stay constant in absolute terms (which is assumed in our simulations). Because in this case household income growth exceeds GDP growth (gI = gY*Y/(Y-G)).

The net wage share in total income is given by:

$$NWS = \frac{(1-t_t^W)(1-mup_t^Y)\alpha(Y_t+FC_Y)P_t^Y + W_t^H L_{At}}{P_t^Y Y_t + W_t^H L_{At} + t_t^C C_t + \Delta B_t - G_t - I_t^G} = \frac{(1-t_t^W)(W_t L_{Yt} + W_t^H L_{At})}{P_t^Y Y_t + W_t^H L_{At} + t_t^C C_t + \Delta B_t - G_t - I_t^G} \quad (19)$$

Since in the simulations we assume that labour taxes are adjusted to balance the budget, a reform measure generally changes the labour tax rate. For simplicity assume that the government has always a balanced budget and uses labour taxes for balancing. This makes the labour tax rate a function of the other budget items:

$$t_t^W (W_t L_{Yt} + W_t L_{At}) = G_t + I_t^G + BEN_t + TR_t - t_t^K i_{t-1}^K P_t^K K_{t-1} - t_t^K i_{t-1}^A P_t^A A_{t-1} - t_t^C C_t, \quad (20)$$

and the net wage share becomes:

$$NWS = GWS - \frac{(G_t + I_t^G + BEN_t + TR_t - t_t^K i_{t-1}^K P_t^K K_{t-1} - t_t^K i_{t-1}^A P_t^A A_{t-1} - t_t^C C_t)}{P_t^Y Y_t + W_t^H L_{At} + t_t^C C_t + \Delta B_t - G_t - I_t^G} \quad (21)$$

An increase in GDP, affects the difference between the net wage and the gross wage share positively. Since capital income and consumption tax revenues rise with an increase of GDP, labour taxes will be reduced via this channel and the net wage share will be positively affected. Also, if unemployment benefits and/or transfer payments decline because of a reform this also has a positive effect on the net wage share.

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