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Growth Effects of Structural Reforms in Southern Europe: The case of Greece, Italy, Spain and Portugal

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Growth Effects of Structural Reforms in Southern Europe:

The case of Greece, Italy, Spain and Portugal

Janos Varga, Werner Roeger and Jan in 't Veld [1]

Abstract

This paper develops a semi-endogenous growth model for analysing the intertemporal effects of structural reforms in Southern European countries (Italy, Spain, Portugal and Greece). The model follows the product variety paradigm in a semi-endogenous setting, and includes a disaggregation of labour into different skill groups. We use a comprehensive set of structural indicators in order to calibrate the model to important macroeconomic ratios and levels of productivity and employment. Our results show that structural reforms yield significant economic gains in the medium and long run. The results point to the importance of product market reforms and labour market related education and tax reforms as the most promising areas of structural policy interventions. This paper also argues for placing more emphasis on education policy which is key in upgrading the labour force, especially in these countries where the share of low skilled labour is among the highest in the euro area.

JEL Classification: E10, O20, O30, O41

Keywords: productivity differences, endogenous growth, R&D, market structure, skill composition, dynamic general equilibrium modelling

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1. Introduction

It is widely recognized that the old member states of the EU have a productivity problem. While the EU reached about 75% of US income per capita in the early 1980s, levels have diverged over the last three decades. Since 2000 Europe's income level has stabilised slightly above 70%. But there is also an income convergence problem within Europe which mostly concerns countries in Southern Europe (SEU). Convergence in these countries also came to a halt in the early 1980s and their relative income level to the US stabilised in the range between 50% (PT) and 65% (ES, IT) at present. These figures most likely provide a too optimistic picture since some of the growth in SEU over the last decade was fuelled by unsustainable fiscal expansion, credit growth and housing booms. Consolidation and deleveraging will slow down growth in the medium term leading to further income divergence. Current intra euro area income gaps in terms of GDP per capita show Italy and Spain at around ¾ of the weighted average of the three highest euro area countries (Luxembourg, Austria and Netherlands), and Portugal and Greece around 55%.

Structural reforms are often advocated as supporting growth. While there is widespread agreement about positive income and employment effects, opinions differ widely about the effects of individual measures, the time profile of the growth benefits and the identification of growth bottlenecks (see, for example Bouis and Duval 2011, Barkbu et al. 2012 and Cacciatore et al., 2012). This paper presents a methodology to assess the impact of structural reforms and identify growth bottlenecks, building on the calibrated semi-endogenous dynamic general equilibrium models of Roeger et al. (2008) and D'Auria et al. (2009).

In developing this framework we have been pursuing the following goals. The first objective is to set up a framework which captures many of the dimensions in current reform discussions, i.e. the model should allow us to make predictions about the impact of labour and goods market reforms. Second, it should be sufficiently detailed to capture market imperfections, regulatory constraints, fiscal burdens (tax wedges and administrative costs) but also allows to analyse constraints imposed by endowments, which for a modern economy are usually skill shortages. Third, given the importance of TFP for long term growth we regarded it as useful to have a framework where TFP is endogenous and is generated by knowledge investment decisions of firms and households. Therefore we have made use of endogenous growth models.

However, a choice has to be made on the type of endogenous growth model we want to use for this exercise. Aghion and Howitt (2006) distinguish three main endogenous growth paradigms. The first version is AK-theory, which is a neoclassical growth model without imposing diminishing returns on capital. The second type of models followed the product-variety paradigm (see Romer, 1990) in which innovation generates endogenous productivity growth by creating new varieties of products. The third paradigm arises from industrial organization theory (see Aghion and Howitt 1992, 1998), and it is commonly referred to as "Schumpeterian" growth theory. This paradigm involves the Schumpeterian notion of creative destruction by focusing on quality improving innovations which forces obsolete products out of the market. Recent models of directed technological change developed in Acemoglu (1998, 2002 and 2007) can be considered as new paradigm in which the direction of technological change is also endogenized.

The product-variety paradigm along with some earlier R&D based models in the literature share the prediction of empirically unjustified scale-effects: if the level of resources devoted to R&D - for instance measured by the number of scientists engaged in R&D - is doubled, then the per capita growth rate of output should also double in the steady state. Jones (1995, 2005) offers an alternative setting for the product-variety paradigm, a semi-endogenous growth model which is free from the inconsistent scale-effects. In this paper we adopt and extend the Jones model to capture the endogenous development of R&D within the framework of a standard Dynamic Stochastic General Equilibrium model. The preference for semi-endogenous growth models to fully endogenous structures is also supported by Bottazzi and Peri (2007) who find evidence of weak scale effects as implied by semi-endogenous models of growth. In addition to the R&D framework, our model also includes the disaggregation of labour into three skill-groups (low-, medium- and high-skilled) in order to capture differences in human capital endowments.

The paper is structured as follows. We begin with a simplified version of our model in order to illustrate how the key features of structural reforms influence long-run GDP and productivity. This simple model provides several of the key insights on the effects of structural reforms, but it is too simple to give a more detailed, country-specific policy modelling framework. In Section 3 we remedy this shortcoming and further enrich the model, followed by more details on the country-specific calibration in Section 4. Section 5 identifies the major reform areas in SEU countries and quantifies the effect of moving the relevant structural indicators to that of the average of the best three euro area performers. Section 6 discusses these results and compares them to other available estimates from the literature. The Appendix of our paper shows the robustness of our results in a series of sensitivity scenarios.

2. A simple model

It is useful to begin with a simplified version of our model in order to see how the key ingredients of structural reform measures fit together to provide an explanation of long-run productivity. To reduce the model, we ignore international spillovers and set up a closed economy growth model with a simple fiscal rule; these features will be introduced in the extended framework of Section 3. Nevertheless the simplified model is already richer compared to Jones (2005) along several dimensions. The Jones (2005) model is a closed economy semi-endogenous model with only one type of households supplying labour services for final and R&D goods production. In order to assess the impact of structural reforms like greater competition in the final goods sector, reducing administrative entry barriers in the intermediate sector, skill-upgrading of the labour force and increasing R&D subsidies, we will introduce additional features into our simplified model. This version introduces mark-ups for the final goods sector and entry costs for the intermediate sector, it features two types of labour: low- and high-skilled offered by households with inelastic labour supply. We introduce a fiscal authority which collects lump-sum taxes from which it pays R&D subsidies.

We assume that monopolistically competitive firms in the final goods sector use an A_t variety of intermediates ($x_{m,t}$). These intermediate goods enter the production function through a CES aggregator with an elasticity of substitution between intermediate goods given by $1/(1-\theta) > 1$. The production function employs the idea of product variety framework proposed by Dixit and Stiglitz

(1977) and applied in the literature of international trade and R&D diffusion[2], and we will explicitly model the underlying development of R&D by the semi-endogenous framework of Jones (1995 and 2005)[3].

In addition to intermediate goods an aggregate ($L_{Y,t}$) of the low- and high-skilled labour types ($L_{LY,t}$ and $L_{HY,t}$ respectively) is employed in the production process:

$$Y_t = \left(\int_0^{A_t} x_{m,t}{}^{\theta} dm \right)^{(1-a)/\theta} L_{Y,t} \tag{1}$$

with unit elasticity of substitution between skills

$$L_{Y,t} = (L_{LY,t})^{\alpha_L} (L_{HY,t})^{\alpha_H}, \quad \text{where } \alpha_L + \alpha_H = \alpha. \tag{2}$$

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 ($L_{RD,t}$):

$$L_{H,t} = L_{HY,t} + L_{RD,t}, \tag{3}$$

and the total labour force grows exogenously at rate n:

$$L_{LY,t} + L_{HY,t} + L_{RD,t} = \left(L_{LY,0} + L_{HY,0} + L_{RD,0} \right) e^{nt}. \tag{4}$$

Invention in the model corresponds to the discovery of a new design by the R&D sector which is used to produce a new variety of intermediate good. Intermediate goods producers rent tangible (physical) capital (K_t) at rate r and purchase the design from the R&D sector which enables them to transform one unit of tangible capital into one unit of intermediate input. This implies the following resource constraint:

$$K_t = \int_0^{A_t} x_{m,t} dm. \tag{5}$$

It is important to note that in a semi-endogenous model the number of varieties (A_t) can be interpreted in multiple ways. It corresponds to the total number of designs (or patents) invented by the R&D sector but at the same time it can be interpreted as the stock of ideas or as the stock of knowledge (or intangible) capital in the economy. Tangible and intangible capital accumulation constraints are given by:

$$\dot{K}_t = Y_t - C_t - \delta K_t \tag{6}$$

$$\dot{A}_t = \nu A_t^{\phi} L_{RD,t}^{\lambda}. \tag{7}$$

Equation (6) is the standard accumulation equation for tangible capital, defined by output (Y_t) less consumption (C_t), assuming a depreciation rate of δ on capital. Equation (7) is the production function for new ideas. As in Jones (2005), new ideas are produced by research labour ($L_{RD,t}$) and the existing stock of knowledge, where parameters ϕ and λ measure the elasticity of new ideas with respect to existing stock of knowledge and the number of researchers respectively. What distinguishes our specification from Jones (2005) is that we have two types of skills and only the high-skilled can work in the R&D sector which makes our specification more suitable to examine the positive effects but also the possible limits of skill-upgrading.

[2] See Grossman & Helpman (1991) and Aghion & Howitt (1998).

[3] Butler and Pakko (1998) also applied (Jones (1995)) semi-endogenous growth framework to examine the effect of endogenous technological change on the properties of a real business cycle model but without skill disaggregation.

The arbitrage condition of entering into the intermediate sector is

$$(1+fc_a)P_{A,t} = \frac{(1+\tau)PR_{\text{int},t}}{r-g_{P_A}}, \quad fc_a > 0, \tag{8}$$

or

$$P_{A,t} = \frac{(1+\tau)PR_{\text{int},t}}{\left(r-g_{P_A}\right)\left(1+fc_a\right)}, \quad fc_a > 0, \tag{8'}$$

where $P_{A,t}$ is the price of designs, $g_{P_A} = \frac{\dot{P}_t^A}{P_t^A}$, fc_a is the (constant) proportion of entry costs in terms of $P_{A,t}$, and $\tau > 0$ is the subsidy rate on profit ($PR_{\text{int},t}$) financed from taxes. To give an economic intuition behind equation (8), it states that the present discounted value of profits exactly meets the required initial investment in intangible capital. Finally, the government collects lump-sum taxes (t_{lump}) which is fully spent on R&D subsidies (τ) at each period:

$$\tau PR_{\text{int},t} = t_{lump} \tag{9}$$

BGP growth rates

To solve for the balanced growth path growth rate of idea (intangible capital) production (g_A), rewrite (7) and use the time-derivatives

$$\frac{\dot{A}_t}{A_t} = \nu A_t^{\phi-1}\left(L_{RD,t}\right)^{\lambda} \rightarrow g_A = \frac{\lambda}{1-\phi}n. \tag{10}$$

In order to obtain the growth rate of output (g_Y), note that from the symmetric structure of the model it follows that for all varieties

$$x_{m,t} = \frac{K_t}{A_t}. \tag{12}$$

Therefore the aggregate production function can be rewritten as

$$Y_t = A_t^{\sigma} K_t^{1-\alpha} L_{Y,t}, \quad \sigma = \left(\frac{1}{\theta}-1\right)\left(1-\alpha\right). \tag{13}$$

The constancy of the capital-output ratio implies that the growth rate of output (g_Y) is given by

$$g_Y = \frac{\sigma}{\alpha} g_A + n. \tag{14}$$

Along the balanced growth path the share of R&D in output, s_A, is constant, therefore:

$$s_A = \frac{P_{A,t}\dot{A}_t}{Y_t} \text{ or equivalently } s_A = \frac{P_{A,t} g_A A_t}{Y_t}, \tag{15}$$

which allows us to solve for the balanced growth rate of intangible capital prices (g_{P_A}):

$$g_{P_A} = \frac{\dot{P}_t^A}{P_t^A} = g_Y - g_A. \tag{16}$$

Intermediate sector's profit

The profit-maximization of the intermediate sector requires the following first order condition:

$$r+\delta=\frac{\theta(1-a)}{1+mkp_f}\left(\int_0^{A_t} x_{m,t}{}^{\theta}dm\right)^{(1-a)/\theta-1} L_{Y,t}x_{m,t}{}^{\theta-1}, \tag{17}$$

where mkp_f denotes the mark-up in the final goods sector. From the symmetric structure of the model (equation 12) follows that

$$r+\delta=\frac{\theta(1-a)}{1+mkp_f}\frac{Y_t}{K_t} \tag{18}$$

and the intermediate sector's profit is given by

$$PR_{\text{int},t}=\frac{(1-\theta)(1-a)}{1+mkp_f}\frac{Y_t}{A_t}. \tag{19}$$

Steady state R&D intensity in output and labour

Along the balanced growth path the share of R&D in output (s_A) can be obtained by substituting (8'), (16) and (19) into (15)

$$s_A=\frac{(1+\tau)(1-\theta)(1-a)g_A}{(1+mkp_f)(r-(g_Y-g_A))(1+fc_a)}. \tag{20}$$

Steady state R&D labour share

To calculate the share of high-skilled labour devoted R&D (s_{RD}) we can use the assumption that high-skilled wages $(W_{H,t})$ are equal across sectors therefore the first order condition with respect to high-skilled labour in the final goods and R&D sector respectively must satisfy that

$$W_{H,t}=\frac{\alpha}{1+mkp_f}\frac{Y_t}{L_{HY,t}}=\lambda\frac{P_{A,t}\dot{A}_t}{L_{RD,t}}. \tag{21}$$

From (21) it follows that the share of high-skilled labour devoted R&D (s_{RD})

$$s_{RD}=\frac{L_{RD,t}}{L_{HY,t}+L_{RD,t}}=\frac{\lambda P_{A,t}\dot{A}_t}{\frac{\alpha}{1+mkp_f}Y_t+\lambda P_{A,t}\dot{A}_t}, \tag{22}$$

which can be expressed in terms of the steady state R&D intensity (s_A):

$$s_{RD}=\frac{\lambda s_A}{\frac{\alpha}{1+mkp_f}+\lambda s_A}=\frac{1}{1+\frac{\alpha}{\lambda(1+mkp_f)s_A}} \tag{23}$$

and using (20)

$$s_{RD}=\frac{1}{1+\frac{\alpha(r-(g_Y-g_A))(1+fc_a)}{\lambda(1+\tau)(1-\theta)(1-a)g_A}} \tag{23'}$$

Equation (23') already reveals some key characteristics of the model. Intuitively, higher R&D subsidies (τ), higher mark-ups in the intermediate sector ($1-\theta$), and lower entry costs (fc_a) make entering into the intermediate goods sector more profitable. As increasing product varieties require more ideas to be produced by the R&D sector and it raises the demand for high-skilled to be employed in the R&D sector i.e. increases the steady state share of high-skilled employed in the R&D sector (s_{RD}). Finally, let us see how the different elements of structural reforms influence labour productivity.

Labour productivity

First we determine the capital stock from the first order condition of the intermediate sector (18):

$$K_t = \frac{(1-\alpha)\theta Y_t}{\left(1+mkp_f\right)\left(r+\delta\right)}. \tag{24}$$

Therefore labour productivity (y_t) is given by

$$y_t = A_t^{\frac{\sigma}{\alpha}}\left(\frac{(1-\alpha)\theta}{\left(1+mkp_f\right)\left(r+\delta\right)}\right)^{\frac{1-\alpha}{\alpha}}\left(\left(1-s_H\right)^{\alpha_L}\left(s_H\left(1-s_{RD}\right)\right)^{\alpha_H}\right)^{\frac{1}{\alpha}} \tag{25}$$

where s_H is the share of high-skilled in total labour, $s_H=L_{H,t}/L_t$.

Along the balanced growth path, the stock of knowledge can be obtained from (10)

$$A_t = \left(\frac{\nu}{g_A}\left(s_{RD}s_H L_t\right)^{\lambda}\right)^{\frac{1}{1-\phi}}, \tag{26}$$

Finally, combining (25) and (26) we obtain that labour productivity along the balanced growth path is

$$y_t = \left(\frac{\nu}{g_A}\left(s_{RD}s_H L_t\right)^{\lambda}\right)^{\frac{\sigma}{\alpha(1-\phi)}}\left(\frac{(1-\alpha)\theta}{\left(1+mkp_f\right)\left(r+\delta\right)}\right)^{\frac{1-\alpha}{\alpha}}\left(\left(1-s_H\right)^{\alpha_L}\left(s_H\left(1-s_{RD}\right)\right)^{\alpha_H}\right)^{\frac{1}{\alpha}} \tag{27}$$

We can now examine the effect of structural reforms on labour productivity with respect to product market competition in the final goods sector, i.e. lowering final goods mark-ups, lower entry costs and higher R&D subsidies in the intermediate sector and skill-upgrading via increasing the share of high-skilled. It is easy to see that decreasing the final good mark-up (decreasing mkp_f) will always lead to higher output per capita because it directly affects the steady-state level of capital. However, the effect of entry costs, R&D subsidies and skill-upgrading is not straight-forward. Increasing the share of high-skilled (s_H) increases the available stock of skilled human resources in both the final goods sector and in the R&D sector. On the other hand, it equivalently decreases the share of low-skilled ($1- s_H$) whose work is also needed to produce final goods, therefore the overall effect is uncertain.

Proposition 1. Increasing the share of high-skilled in the model will increase labour productivity if

$$\frac{1}{1+\frac{\alpha_L}{\frac{\lambda\sigma}{1-\phi}+\alpha_H}} > s_H \tag{28}$$

Proof:

Note that the derivative of labour productivity w.r.t. s_H is proportional to

$$\frac{\partial y_t}{\partial s_H} \propto \frac{\partial}{\partial s_H}\left((s_H)^{\frac{\lambda\sigma}{1-\phi}+\alpha_H} (1-s_H)^{\alpha_L} \right) \tag{28'}$$

After rearranging the derivative, one arrives at (28).

Note that (28) sets a limit above which increasing high-skilled share will not increase labour productivity. Intuitively since not only high-skilled but also low-skilled are needed to produce final output, this limit is higher the larger the elasticity of final goods production with respect to the high-skilled employed in the final-goods sector and in the R&D sector respectively $\left(\frac{\lambda\sigma}{1-\phi}, \text{and } \alpha_H\right)$ and equivalently, the smaller is the elasticity of final goods production w.r.t the low-skilled employment.

The effect of entry costs and R&D subsidies is slightly more involved and it is linked to the trade-off of allocating resources between the final and R&D goods sector. Note that entry costs and R&D subsidies influence labour productivity via the steady-state share of R&D labour. As we have seen from equation (23') earlier, higher R&D subsidies (τ) and lower entry costs (fc_a) make entering into the intermediate goods sector more profitable thereby stimulating more R&D and inducing higher R&D labour share. Equation (27) also reveals another important trade-off in our model, one can increase the share of R&D labour only on the cost of decreasing the share of high-skilled available for the final goods sector which in turn can reduce labour productivity.

Proposition 2. Increasing the share of high-skilled employed in the R&D sector by decreasing entry costs or increasing R&D subsidies will increase labour productivity if

$$\frac{1}{1+\frac{\alpha_H}{\frac{\lambda\sigma}{1-\phi}}} > s_{RD} \tag{29}$$

Proof:

Note that the derivative of labour productivity w.r.t. s_{RD} is proportional to

$$\frac{\partial y_t}{\partial s_{RD}} \propto \frac{\partial}{\partial s_{RD}} (s_{RD})^{\frac{\lambda\sigma}{1-\phi}} (1-s_{RD})^{\alpha_H} \tag{29'}$$

After rearranging the derivative, one arrives at (29).

In parallel with increasing the share of high-skilled, higher proportion of R&D-employment does not necessary lead to higher labour productivity because high-skilled labour force is also required to produce final goods. The threshold below which increasing R&D subsidies and decreasing entry costs will stimulate R&D employment so that labour productivity is increasing depends on the relative elasticity of R&D labour versus high-skilled workers in the final goods sector: $\alpha_H / \frac{\lambda\sigma}{1-\phi}$.

3. The extended model

The simple model given in the previous section provides several of the key insights of the effects of structural reforms, but it is too simple to provide a more detailed, country-specific policy framework. In this section, we remedy this shortcoming and further extend the model. We augment our simple model with the addition of two types of households, liquidity and non-liquidity constrained, a feature which has become a de facto standard in dynamic stochastic general equilibrium modelling. We consider three types of labour skills that allow us to conduct more detailed human capital reforms. The model also includes a fiscal and monetary authority with the appropriate decision rules. Importantly, our extended model is a multicountry model in which individual country blocks are interlinked with international trade and knowledge spillovers. Finally, while Jones (1995, 2005) were theoretical, illustrative models, we bring our model to data and calibrate it on actual data of the countries of interest.

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 existing stock of domestic and foreign ideas. Technological change is modelled as increasing product variety in the tradition of Dixit & Stiglitz (1977).

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[4] $(bW_{s,t})$, transfer income from the government $(TR_{i,t})$, and interest

[4] Households only make a decision about the level of employment but there is no distinction on the part of households between unemployment and non-participation. It is assumed that the government makes a decision how to classify the non-working part of the population into unemployed and non-participants. The non-participation rate (NPART) must therefore be seen as a policy variable characterising the generosity of the benefit system.

income (i_t, $i_{K,t}$ and $i_{A,t}$). Hence, non-liquidity constrained households face the following Lagrangian

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

$$- E_0 \sum_{t=0}^{\infty} \lambda_{i,t} \frac{\beta^t}{P_t} \left(\begin{matrix} (1+t_{C,t}) P_{C,t} C_{i,t} + B_{i,t} + P_{I,t} \left(J_{i,t} + \Gamma_J (J_{i,t}) \right) + P_{A,t} J_{A,i,t} \\ -\left(1 + i_{t-1}\right) B_{i,t-1} \\ -\sum_s \left(1 - t_{w,s,t}\right) W_{s,t} L_{i,s,t} - bW_{s,t} (1 - NPART_{i,s,t} - L_{i,s,t}) \\ -(1 - t_K)(i_{K,t-1} - rp_K) P_{I,t-1} K_{i,t-1} - t_K \delta_K P_{I,t-1} K_{i,t-1} - \tau_K P_{I,t} J_{i,t} \\ -(1 - t_K)(i_{A,t-1} - rp_A) P_{A,t-1} A_{i,t-1} - t_K \delta_A P_{A,t-1} A_{i,t-1} - \tau_A P_{A.t} J_{A,i,t} \\ -TR_{i,t} - \sum_{j=1}^{N} PR_{fin,j,i,t} - \sum_{m=1}^{A_t} PR_{\text{int},m,i,t} \end{matrix} \right), \quad (30)$$

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

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, $\sum_{j=1}^{N} PR_{fin,j,i,t}$ and $\sum_{m=1}^{A_t} PR_{\text{int},m,i,t}$, 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 ($t_K \delta_K$ and $t_K \delta_A$) 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.

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.

$$U(C_{i,t}) = (1 - habc) \log\left(C_{i,t} - habcC_{t-1}\right). \quad (31)$$

For leisure 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

$$V(1 - L_{i,s,t}) = \frac{\omega_s}{1 - \kappa} (1 - L_{i,s,t})^{1-\kappa} \quad (32)$$

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

$$\Gamma_J(J_{i,t}) = \frac{\gamma_K}{2}\frac{\left(J_{i,t}\right)^2}{K_{i,t-1}} + \frac{\gamma_I}{2}(\Delta J_{i,t})^2. \tag{33}$$

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

$$\frac{\partial V_0}{\partial C_{i,t}} => U_{C,i,t} - \lambda_{i,t}(1+t_{C,t})\frac{P_{C,t}}{P_t} = 0 \tag{34a}$$

$$\frac{\partial V_0}{\partial B_{i,t}} => -\lambda_{i,t} + E_t\left(\lambda_{i,t+1}\beta\left(1+i_t\right)\frac{P_t}{P_{t+1}}\right) = 0 \tag{34b}$$

$$\frac{\partial V_0}{\partial K_{i,t}} => E_t\left(\lambda_{i.t+1}\frac{\beta P_{I,t}}{P_{t+1}}\Big((1-t_K)(i_{K,t} - rp_K) + t_K\delta_K\Big)\right) - \lambda_{i,t}\xi_{i,t} + E_t\Big(\lambda_{i,t+1}\xi_{i,t+1}\beta(1-\delta_K)\Big) = 0 \tag{34c}$$

$$\frac{\partial V_0}{\partial J_{i,t}} => -\left(\left(1+\gamma_K\left(\frac{J_{i,t}}{K_{i,t-1}}\right)+\gamma_I\Delta J_{i,t}\right)-\tau_K\right) + E_t\left(\frac{1}{1+i_t}\frac{P_{I,t+1}}{P_{I,t}}\gamma_I\Delta J_{i,t+1}\right) + \xi_{i,t}\frac{P_t}{P_{I,t}} = 0. \tag{34d}$$

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

$$\frac{\partial V_0}{\partial A_{i,t}} => E_t\left(\lambda_{i.t+1}\frac{\beta P_{A,t}}{P_{t+1}}\Big((1-t_K)(i_{A,t} - rp_A) + t_K\delta_A\Big)\right) - \lambda_{i,t}\psi_{i,t} + E_t\Big(\lambda_{i,t+1}\psi_{i,t+1}\beta(1-\delta_A)\Big) = 0 \tag{35a}$$

$$\frac{\partial V_0}{\partial J_{A,i,t}} => -\frac{P_{A,t}}{P_t}\left(1-\tau_A\right) + \psi_{i,t} = 0 \tag{35b}$$

Therefore the rental rate can be obtained from (35a), (35b) and (34b):

$$i_{A,t} = E_t\left(\frac{\left(1-\tau_A\right)\left(i_t - \pi_{A,t+1} + \delta_A + \delta_A\pi_{A,t+1}\right) - t_K\delta_A}{1-t_K}\right) + rp_A \tag{35c}$$

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

Equation (35c) 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 optimize 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:

$$(1+t_{C,t})P_{C,t}C_{k,t} = \sum_{s\in\{L,M,H\}} \left(\left(1-t_{w,s,t}\right)W_{s,t}L_{k,s,t} + bW_{s,t}(1-NPART_{k,s,t}-L_{k,s,t})\right)+TR_{k,t}. \tag{38}$$

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[5]. 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

$$\frac{U_{1-L,h,s,t}}{U_{C,h,s,t}}\frac{1}{\eta_{s,t}} = \frac{W_{s,t}(1-t_{w,s,t}-b)}{P_{C,t}(1+t_{C,t})} \text{ for } s\in\{L,M,H\} \tag{39}$$

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

$$X_t = \int_0^1 X_{h,t}dh = (1-\varepsilon)X_{i,t} + \varepsilon X_{k,t}, \tag{40}$$

Hence aggregate consumption and employment is given by

$$C_t = (1-\varepsilon)C_{i,t} + \varepsilon C_{k,t} \tag{41}$$

and

$$L_t = (1-\varepsilon)L_{i,t} + \varepsilon L_{k,t}. \tag{42}$$

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 a fixed cost FC

$$Y_t = \left(L_{Y,t}\right)^{\alpha}\left(\sum_{m=1}^{A_t}\left(x_{m,t}\right)^{\theta}\right)^{\frac{1-\alpha}{\theta}} - FC \tag{43}$$

with

$$L_{Y,t} = \left(\Lambda_L^{\frac{1}{\mu}}\left(\chi_L L_{L,t}\right)^{\frac{\mu-1}{\mu}} + \Lambda_M^{\frac{1}{\mu}}\left(\chi_M L_{M,t}\right)^{\frac{\mu-1}{\mu}} + \Lambda_{HY}^{\frac{1}{\mu}}\left(\chi_{HY} L_{HY,t}\right)^{\frac{\mu-1}{\mu}}\right)^{\frac{\mu}{\mu-1}} \tag{44}$$

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[5] The mark-up depends on the intratemporal elasticity of substitution between differentiated labour services within each skill groups (σ_s) and fluctuations in the mark-up arise because of wage adjustment costs and the fact that a fraction (1-*sfw*) of workers is indexing the growth rate of wages π_W to wage inflation in the previous period $\eta_{s,t} = 1-1/\sigma_s - \gamma_W/\sigma_s\left[\beta(sfw\pi_{W,t+1}-(1-sfw)\pi_{W,t-1})-\pi_{W,t}\right]$.

$L_{L,t}$, $L_{M,t}$ 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 $\left(z \in \{L, M, HY\}\right)$, χ_z is the efficiency unit, and μ is the elasticity of substitution between different labour types. Remember from our simplified model that high-skilled labour in the final goods sector, $L_{HY,t}$, is the total high-skill employment minus the high-skilled labour working for the R&D sector ($L_{RD,t}$), equivalently:

$$L_{H,t} = L_{HY,t} + L_{RD,t}\,. \tag{45}$$

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

$$\alpha \frac{Y_t}{L_{Y,t}} \left(\frac{L_{Y,t}}{L_{z,t}} \right)^{\frac{1}{\mu}} \Lambda_z^{\frac{1}{\mu}} \chi_z^{\frac{\mu-1}{\mu}} \eta = W_{z,t}, \quad z \in \{L, M, HY\} \tag{46}$$

$$px_{m,t} = \eta(1-\alpha)Y_t \left(\sum_{m=1}^{A_t} \left(x_{m,t}\right)^{\theta} \right)^{-1} \left(x_{m,t}\right)^{\theta-1} \tag{47}$$

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

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 (47), therefore the first order condition is

$$\theta\eta(1-\alpha)Y_t \left(\sum_{m=1}^{A_t} \left(x_{m,t}\right)^{\theta} \right)^{-1} \left(x_{m,t}\right)^{\theta-1} = i_{K,t} \tag{48}$$

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

$$px_{m,t} = \frac{i_{K,t}}{\theta} \tag{49}$$

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

$$PR_{\text{int},m,t} = i_{A,t} P_{A,t} + \left(i_{A,t} + \pi_{A,t+1}\right) FC_A, \quad \forall m \tag{50}$$

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:

$$\Delta A_t = \nu A_{t-1}^{*\ \varpi} A_{t-1}^{\phi} \left(L_{RD,t}\right)^{\lambda}. \tag{51}$$

In this framework we allow for international R&D spillovers following Bottazzi & Peri (2007). Parameters ϖ 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 $\phi = 1$ 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 maximizes the following discounted profit-stream:

$$\max_{L_{RD,t}} \sum_{t=0}^{\infty} d_t \left(P_{A,t}\Delta A_t - W_{H,t} L_{RD,t} - \frac{\gamma_A}{2} W_{H,t} \left(\Delta L_{RD,t}\right)^2 \right) \tag{52}$$

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

$$BEN_t = \sum_{s\in\{L,M,H\}} bW_{s,t}(1 - NPART_{s,t} - L_{s,t}). \tag{53}$$

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

$$SUB_t = t_K \left(\delta_K P_{I,t-1} K_{i,t-1} + \delta_A P_{A,t-1} A_{i,t-1}\right) + \tau_K P_{I,t} J_{i,t} + \tau_A P_{A.t} J_{A,i,t}. \tag{54}$$

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

$$B_t = (1+i_t)B_{t-1} + G_t + IG_t + TR_t + BEN_t + SUB_t - R_t^G. \tag{55}$$

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

$$\Delta t_{w,t} = \tau_B \left(\frac{B_{t-1}}{Y_{t-1}} - b^T \right) + \tau_{DEF} \Delta\left(\frac{B_t}{Y_t} \right), \tag{56}$$

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 .

$$i_t = \gamma_{ilag} i_{t-1} + (1-\gamma_{ilag})(r_{EQ} + \pi_{TAR} + \gamma_{\inf}(\pi_{C,t} - \pi_{TAR}) + \gamma_{ygap}\hat{y}_t). \tag{57}$$

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 $(\hat{y}_t)$ 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:

$$Z_t = \left((1-\rho)^{\frac{1}{\sigma_{im}}} Z_{d,t}^{\frac{\sigma_{im}-1}{\sigma_{im}}} + \rho^{\frac{1}{\sigma_{im}}} Z_{f,t}^{\frac{\sigma_{im}-1}{\sigma_{im}}} \right)^{\frac{\sigma_{im}}{\sigma_{im}-1}}, \tag{58}$$

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

4. Calibration

We calibrate our model in a multicountry setting for the four Southern euro area member states, the rest of the euro area 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. We restrict our sensitivity analysis in the Appendix to some of the parameters which are taken from empirical estimates in the literature or where the mapping between our variables and the corresponding statistical data is less straightforward.

Goods Market:

We identify the intermediate sector as the manufacturing sector and the final goods sector as the aggregate of all remaining market sectors. The manufacturing sector resembles the intermediate sector along various dimensions. First, this sector is more R&D and patent intensive, second, a large fraction of manufacturing supplies innovative goods (in the form of investment 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 manufacturing 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 the method suggested by Roeger (1995). 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 ϖ, only the ratio between these coefficients and λ. These estimates together with the long-run growth rate of intangible capital (equation 10) and λ pin down the corresponding elasticities. Since country-specific elasticities are not available, in the Appendix we perform a sensitivity test with respect to lower domestic and higher foreign knowledge elasticity share in the Southern euro area states.

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 and in the Appendix we explore the sensitivity of our results by setting it to 1.4 as estimated by KM. 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:

$$\chi_M = \left(\frac{W_{M,t}}{W_{L,t}}\right)^{\frac{\mu}{\mu-1}} \left(\frac{\Lambda_M}{\Lambda_L}\right)^{\frac{1}{1-\mu}} \left(\frac{L_{M,t}}{L_{L,t}}\right)^{\frac{1}{\mu-1}} \chi_L \tag{59}$$

$$\chi_{HY} = \left(\frac{W_{H,t}}{W_{M,t}}\right)^{\frac{\mu}{\mu-1}} \left(\frac{\Lambda_{HY}}{\Lambda_M}\right)^{\frac{1}{1-\mu}} \left(\frac{L_{HY,t}}{L_{M,t}}\right)^{\frac{1}{\mu-1}} \chi_M . \tag{60}$$

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. Since wage-premiums play a crucial role in determining the skill-specific efficiency parameters, in the Appendix we will test the robustness of our results under alternative wage-premium settings.

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 Warda (2009) and OECD (2013). Monetary policy parameters are adopted from Ratto et al. (2009) while the bilateral trade data is obtained from the EUROSTAT/COMEXT database. Table 1 gives an overview of the major structural parameters discussed above.

Table 1. Calibration of main structural parameters

Variable/Parameter	Greece	Italy	Portugal	Spain	Source
R&D sector					
L_{RD}	1.0	1.0	1.2	1.2	EUROSTAT
R&D intensity (% GDP)	0.8	1.5	1.7	1.4	EUROSTAT
λ	0.6	0.6	0.7	0.6	constrained by equations
ϕ	0.4	0.5	0.3	0.4	Bottazzi-Peri (2007)
ϖ	0.5	0.5	0.7	0.6	Bottazzi-Peri (2007)
ν	1.0	0.6	1.1	0.8	constrained by equations
Final and intermediate goods sector					
final goods mark-up	34.5	14.0	22.7	22.7	Commission services
intermediate goods mark-up	12.3	10.7	8.8	8.6	Commission services
risk-premia on intangibles	4.6	3.0	3.3	3.8	constrained by equations
fixed entry costs	20.1	18.2	2.3	4.7	www.doingbusiness.org
Labour, skills distribution					
s_L	34.3	42.8	62.4	45.6	EUROSTAT
s_M	59.0	53.1	33.6	44.7	EUROSTAT
s_H	6.7	4.1	4.1	9.7	EUROSTAT
μ (elasticity of substitution between skills)	1.7	1.7	1.7	1.7	Acemoglu and Autor (2011)
Skill premium % (high vs. medium)	34.4	54.7	35.8	37.2	EUROSTAT
Skill premium % (medium vs. low)	16.4	38.2	94.7	38.1	EUROSTAT
Frisch elasticity of labour supply	0.4	0.4	0.4	0.4	Chetty (2012)
Taxes and subsidies					
R&D tax-credit	0.01	0.12	0.49	0.34	Warda (2009) OECD (2013)
Labour taxes	30.9	42.3	25.5	33.2	EUROSTAT
Consumption taxes	16.3	17.4	18.0	14.0	EUROSTAT

5. Quantifying the impact of structural reforms in Southern Europe

In order to assess the potential impact of structural reforms we first identify reform needs by comparing structural indicators in the area of goods and labour markets as well as innovation policies. This indicates how far a country is from 'best practice' (distance-to-frontier) and where there is room for improvement. Our benchmarking approach quantifies the reform potential as a closure of the gaps in different structural indicators with the average of the three best performing countries in the euro area[6]. We concentrate on structural indicators in the following areas: competition in the final goods sector (mostly services and network sectors), intermediate firms' entry barriers (mostly innovative start-ups), the structure of direct and indirect taxes, government support to private R&D, and the skill composition of the labour force.

Market competition

In standard general equilibrium models, product market reforms are typically simulated by negative mark-up shocks. Several studies found that potential gains in output and employment from improving competition in the euro area may be significant (e.g. Bayoumi et al., 2004, Kilponen and Ripatti, 2006, Almeida et al., 2010, Bouis and Duval, 2011). A mark-up reduction in the final goods sector increases the demand for all factors of production in our model (tangible capital, intangible capital and labour). With the exception of Italy, the Mediterranean countries have significantly higher mark ups in final goods sectors compared to our euro area benchmark (average of the three lowest mark-ups, see Figure 1. below). Tables 2-5 show the impact on GDP and employment from reducing final goods mark ups in Greece, Italy, Portugal and Spain to our benchmark value. Since competition enhancing reforms take a long time to implement and to become effective, the mark-up reduction simulations assume gradual implementation of 1 pp. decline per year. The simulations show that product market reforms cannot yield gains in the short run. GDP and employment could actually fall slightly below baseline in the first years after the reforms. However, in the medium to long run the macroeconomic gains are significant. After 5 years GDP is more than 3% higher in Greece, between 2 ½-3% higher in Spain and Portugal, and 0.3% in Italy, which has according to our estimates already relatively low mark-ups. In the long run GDP gains are even larger, ranging from 1.2% (Italy) to 39.3% (Greece).

Entry costs

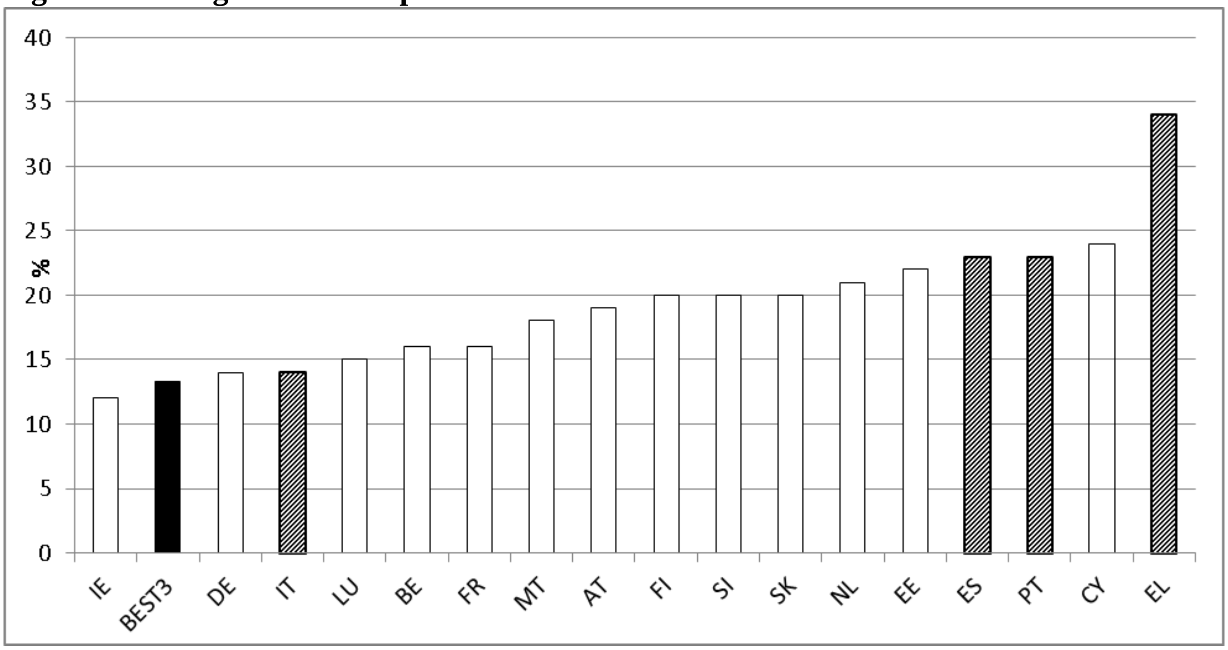
Empirical studies link cross-country differences in growth performance to the degree of market regulation. Nicoletti and Scarpetta (2003) find a negative relationship between multi-factor productivity (MFP) and economy-wide and sector-specific entry barriers. For EU countries with high entry costs, the authors estimate that entry liberalisation in service industries boosted annual MFP growth in the overall business sector by about 0.1-0.2 percentage points. Alesina et al. (2005) provide robust evidence that entry barriers have negative effect on investments. Buttner (2006) finds that reducing entry fees increases the steady state rate of innovation and stimulates growth.

The Mediterranean countries have the highest level of entry barriers measured by the World Bank's *Doing Business* indicators (see Figure 2). In the long run, reducing these barriers to the euro area benchmark level promises significant economic gains for the three most effected countries:

[6] The average of the best three indicators will be the benchmark in each of the simulation scenarios respectively.

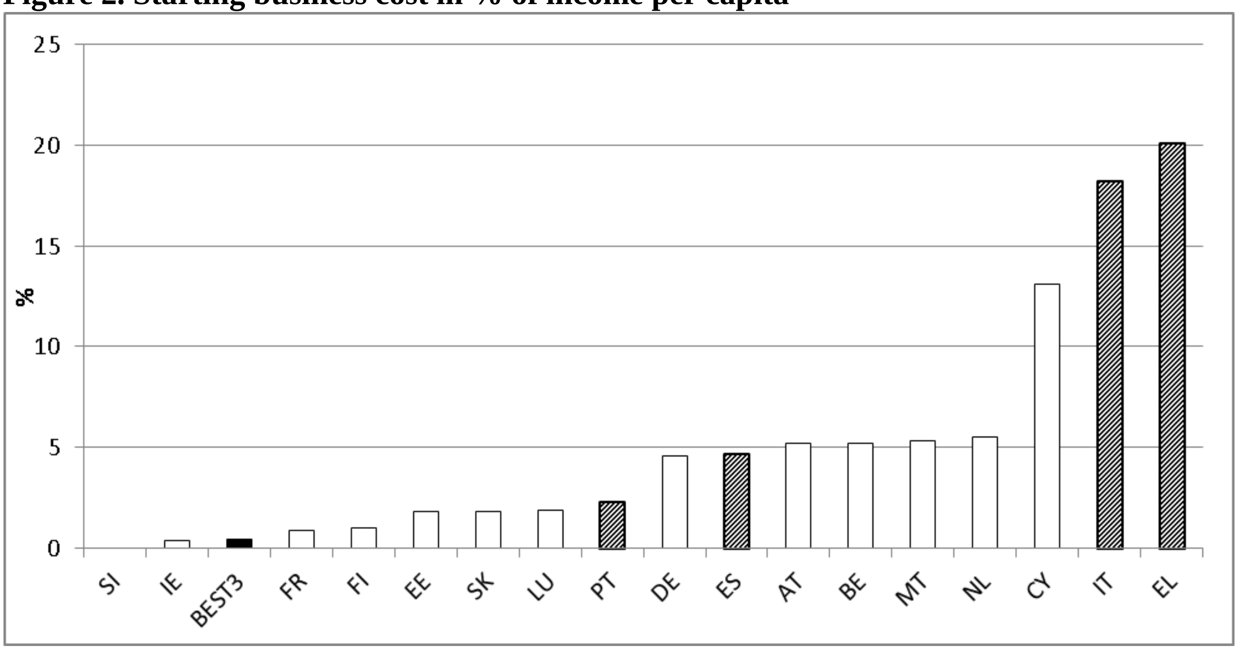
Greece, Italy and, to a lesser extent, Spain. Decreasing entry costs lowers the profits requirement for intermediate producers, which represent the manufacturing sector in the model, and thereby increases the entry of new firms. The growing number of new entrants translates into higher demand for patents and increases the demand for high skilled workers. In our simulation exercise, this can boost GDP in the medium/long run. After 5 years, GDP in Greece is 0.8% higher, while in the long-run GDP gains are ranging from 0.2% (Portugal) to 7.9% (Greece).

Figure 1. Final goods mark ups in the euro area



Source: Commission estimates.

Figure 2. Starting business cost in % of income per capita

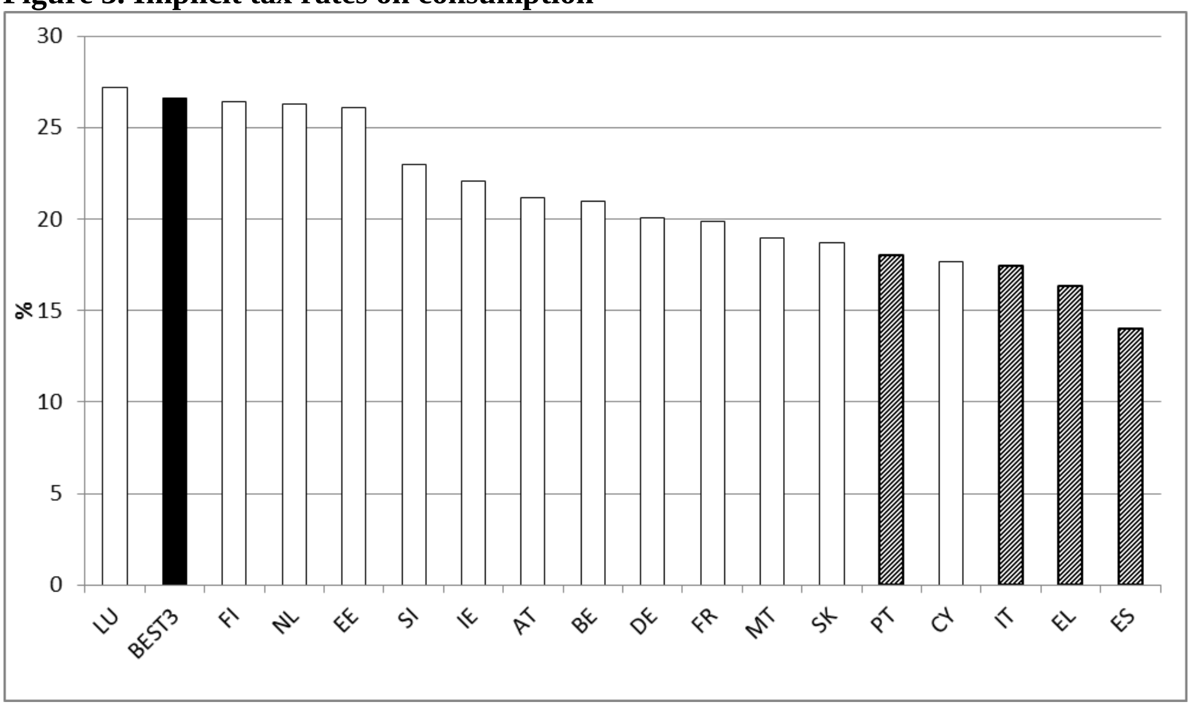


Source: www.doingbusiness.org, 2012 data

Tax shift from labour to consumption taxes

The cross country comparison of Figure 3 reveals that Greece, Italy, Portugal and Spain have some of the lowest implicit tax rates on consumption in the euro area. This leaves considerable scope for shifting the burden of taxation from labour incomes to consumption. This would make returns to labour income more attractive and hence encourage employment, particularly at the lower end of the wage distribution. This hypothesis also finds support in empirical works which identify a positive link between tax shifts and growth. For example, Garcia-Escribano and Mehrez (2004), using a panel data of 18 OECD countries, finds that lowering the share of direct taxes in total revenues by 3 percentage points (while raising the share of indirect taxes by the same amount) would raise growth by 0.25 percentage point. The overall effects of such a tax shift will depend on how other income groups are compensated for the tax increase. Tables 2 to 5 show the effects of reducing labour taxes in the four Mediterranean countries. In each case we increase the implicit consumption tax rate to the average of the highest three euro area consumption tax rates in a budgetary neutral way, so that simultaneously labour taxes can be reduced.[7] The reduction in labour tax leads to an increase in employment and in output. The source of the positive employment (and GDP) effect is due to the shift in taxation from wages to income from financial wealth and transfers by assuming that benefits and transfers are not indexed to consumer price inflation.[8] In our simulations, GDP is after 5 years 0.5% higher in Portugal, 0.7% in Italy, 1.0% in Spain and 1.4 in Greece. The long run GDP gain ranges from 1.9 % (Portugal) to 4.5 % (Greece). Long-run employment gains range from 1.8% to 4.7%.

Figure 3. Implicit tax rates on consumption



Source: EUROSTAT, 2011 data.

[7] The shocks were calibrated based on the relevant tax-bases from Eurostat (2012 data), consumption and wage shares respectively in an ex-ante budgetary neutral setting.

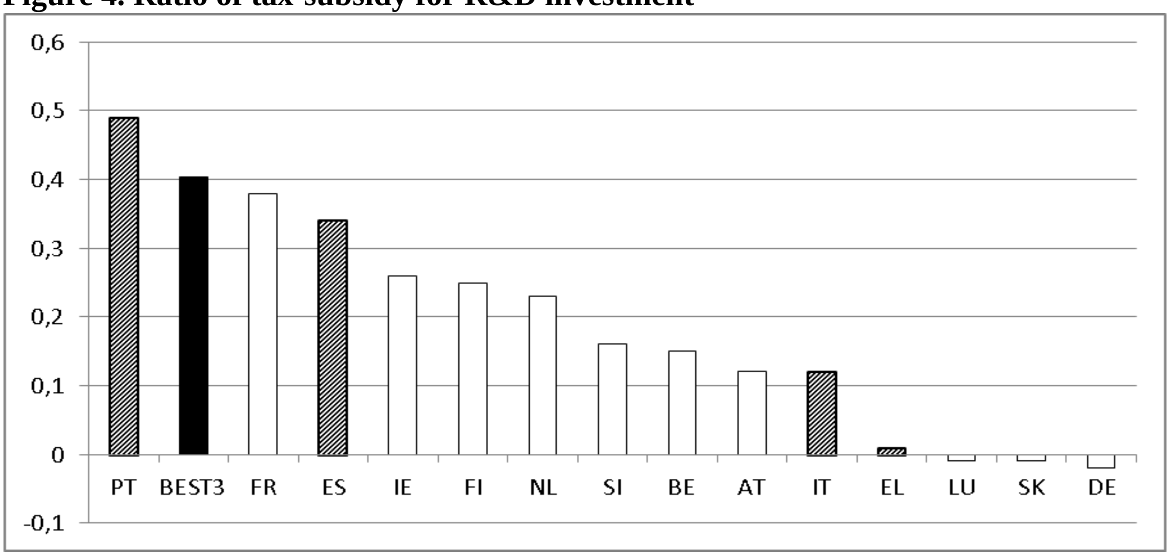
[8] Indexation of transfers to consumer price inflation would mean that non-wage income is compensated for the consumption tax increase, which would result in less positive employment and GDP effect.

R&D and human capital investment

A growing body of literature focuses on the efficiency of fiscal incentives in raising R&D. The seminal article of Bloom et al. (2002) examines the effect of tax credits on the level of R&D investment for a panel of OECD countries, finding that a decrease of 10% in the cost of R&D increases its level by approximately 1% in the short run and close to 10% in the long run. Guellec and van Pottelsberghe (2003) also analyse the impact of R&D funding in OECD countries and conclude that the effect of tax incentives is positive and most effective when the policy is stable over time. Interestingly, the authors find evidence of decreasing return on government subsidies with respect to stimulate business R&D.

Government subsidies to private R&D (Figure 4) offer limited growth potentials in our model because the support to private innovation leads to a reallocation of high skilled workers from the production sector to the R&D sector. The increase in tax credits allows the non-liquidity constrained households to lower the rental rate for intangibles, thereby reducing the fixed costs faced by intermediate goods producers. This translates into a rise in the demand for patents and stimulates R&D. In the short-run, the reallocation of high-skilled labour to R&D reduces final goods production and has a negative impact on growth, but in the medium and long-run, the positive output effects dominate as productivity increases. Due to the supply constraints for high skilled workers, part of the fiscal stimulus is offset by wage increases for these workers. The long-run GDP effects are the largest for Greece and Italy, the countries with the lowest current R&D tax-credits, but still it is only about 1.4% and 0.9% respectively. It is important to note that the model can only stimulate the effect of public subsidies to private R&D, e.g. in the form of tax-incentives. Subsidies to R&D in public research institutes or universities could have different transmission channels and even less crowding out effects because business financed R&D programmes typically focus on applied research while public research institutes and universities typically concentrate on basic research programmes which are too costly or less profitable for private R&D firms to undertake.

Figure 4. Ratio of tax-subsidy for R&D investment



Note: Tax subsidies are calculated as the share of tax relief after 1 US dollar R&D investment. For example, in Spain, 1 unit of R&D expenditure by large firms results in 0.35 unit of tax relief. Source: Warda (2009) and OECD (2013), data points are missing for Cyprus, Estonia, and Malta.

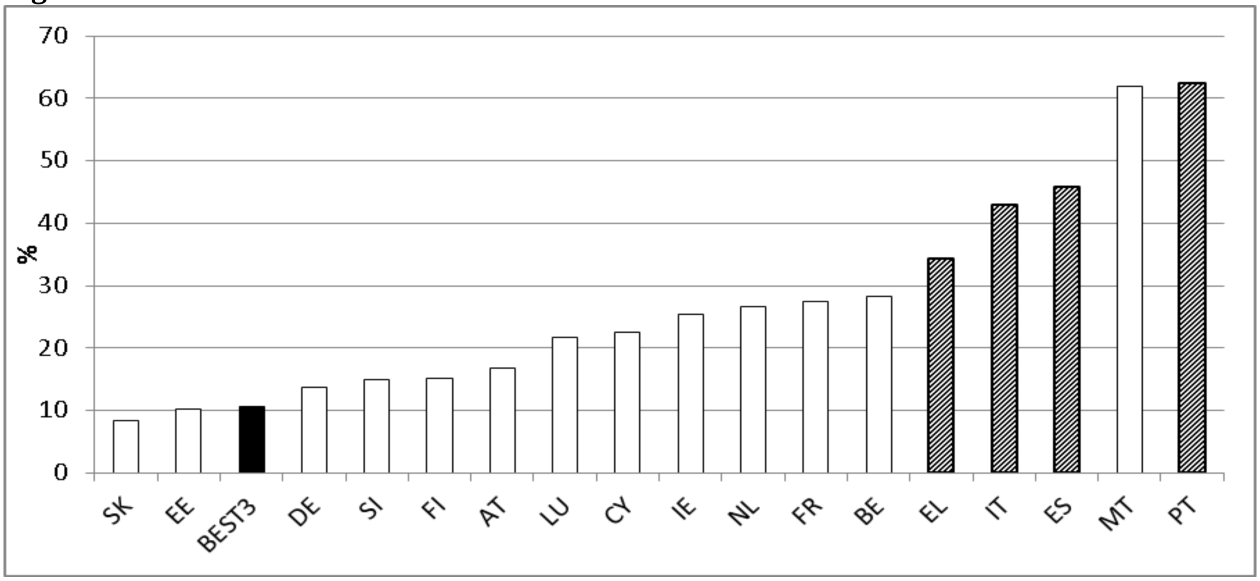
There is a recent trend that governments try to make their countries more attractive location for R&D investments than their competitors. According to Thursby and Thursby (2006), direct or indirect fiscal incentives might be less important for the decisions of multinationals to locate their R&D activities in a particular country. The authors find that for companies locating in developed countries, the most relevant factors in order of importance were the quality of R&D personnel, the quality of intellectual property protection, the expertise of university faculty, the ease of collaborating with universities, and market factors such as access to markets and their growth potential. This leads us to the last area of reforms considered in this note, namely investments in human capital formation.

A large body of theoretical and empirical literature supports the key role of human capital formation in economic growth. In a growth accounting exercise, Jones (2002) concludes that around one third of US growth between 1950 and 1993 can be attributed to human capital accumulation. The enormous economic potential of educational reforms has been stressed in a recent paper by Hanushek and Woessmann (2012). The authors estimate that by bringing each European Union member states up to the top-performer Finland's education quality standards, the present value of the gains from such educational reforms could add up to almost eight times of current EU GDP or, in other terms, it would increase the level of GDP by about 20%.

This exercise considers a less ambitious goal: reaching the average of the best three euro area population shares without accounting for education quality standards. There are budgetary costs for increasing education spending, and this may make it difficult to introduce these reforms in times of fiscal austerity. But the effects in the medium long run can be large. Figure 5 and 6 show that the Mediterranean countries have large gap w.r.t. medium skilled population share, i.e. these countries have the largest shares of low-skilled among the euro area countries. There is also some scope for improvement for the high skilled shares (Figure 6). Reaching our benchmark euro area skill distribution promises significant economic gains for all countries. However, the effect of schooling takes time to build up due to the cohort effects and the gains are only becoming apparent in the medium term. Nonetheless the effects become large and highly persistent (see Tables 2-5). These areas of structural reforms are the most promising ones for Italy and Portugal, accounting for around 23% and 34% long-run GDP increase respectively (combined effect of the two education reforms).

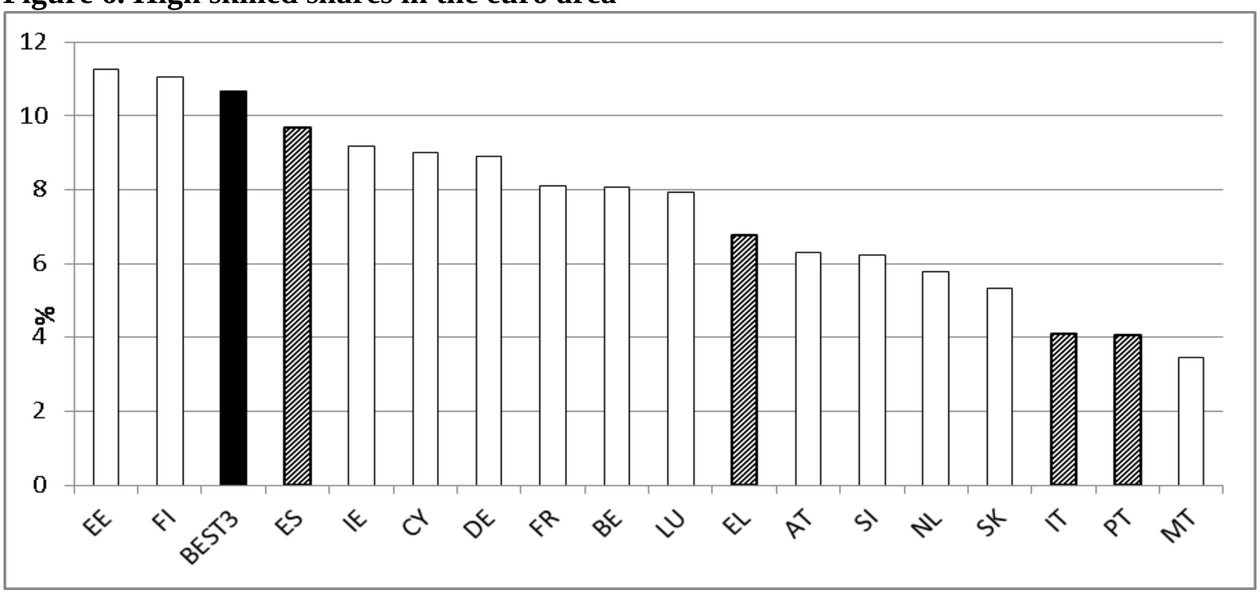
It is important to note that although education reforms can bring sizable economic gains in the long-run, one cannot expect significant benefits from these reforms in the short run because cohort effects take time to be fully reflected in the labour force. Therefore the later the skill supply problems are addressed, the later the member states can reap the long-run benefits and in the meantime the more they will fall behind the innovation frontiers.

Figure 5. Low skilled shares in the euro area



Source: EUROSTAT, 2012 data

Figure 6. High skilled shares in the euro area



Note: High-skilled are defined as human resources in science, mathematics and computing, engineering, manufacturing and construction and do not correspond to the commonly used ISCED 5-6 education attainment definition. Low-skilled belong to the ISCED 0-2 categories and the rest of the population is defined as medium-skilled. Source: EUROSTAT, 2012 data

Taking stock

Tables 2 to 5 show that these reforms can account for a substantial proportion of the current GDP-per-capita gap between the selected Mediterranean countries and the average of the best three euro area performers (as of 2012). The aggregate effect of these reform scenarios can account for about 78% of gap in Greece, 87% in Italy, 99% in Spain, and 67% in Portugal[9]. Reforming the product market yields the highest GDP gains in Greece. All four countries would largely benefit in the long run from skill-upgrading of their labour force. Short term gains can mostly be expected from tax shifts towards higher VAT (and lower labour taxes). In terms of employment gains, tax reforms and skill-upgrading in the form of increasing the share of medium and high-skilled labour supply can help the most to increase the employment rate in the long-run. In the case of Portugal the reforms simulated here can only explain part of the income gap, and factors like high overhead labour, in particular in the non-market sector, also play a role.

Table 2. Greece: GDP and employment effects of structural reforms

Stylised policy impulse	**size**		**GDP effect (% deviation from baseline)**					**Employment effect (% deviation from baseline)**				
Years			**1**	**2**	**5**	**10**	**long run**	**1**	**2**	**5**	**10**	**long run**
Product market												
Reducing final goods market mark-up	-20.7	pp.	-1.1	-0.3	3.4	8.1	39.3	-1.3	-0.7	2.2	3.8	11.5
Reducing intermediate firms' entry barriers	-19.7	pp.	-0.1	-0.1	0.8	2.4	7.9	0.2	0.1	0.1	0.1	1.9
Labour market												
Tax-shift from labour to consumption	-10.3	pp.	1.0	1.2	1.4	2.2	4.5	1.3	1.9	2.7	3.5	4.7
Knowledge and innovation												
R&D subsidy	39.5	pp.	0.0	-0.2	-0.4	0.4	1.4	-0.2	-0.1	0.2	0.0	-0.2
Decreasing the share of low skilled workers	-24.5	pp.	0.0	0.0	0.2	0.5	3.8	0.0	0.0	0.2	0.3	2.9
Increasing the share of high skilled workers	3.9	pp.	0.0	0.0	0.0	0.1	3.9	0.0	0.0	0.0	0.1	1.2
Total			-0.3	0.7	5.4	13.8	60.8	0.0	1.2	5.3	7.8	22.0

Note: % deviations from baseline. GDP per capita in Greece was 56% of the weighted average of the three highest GDP per capita ratios in the euro area in 2012 (Luxemburg, Austria, and the Netherlands). These measures can account for 78% of the current income gap.

[9] Note that the results of individual reform scenarios are additive. Long-run effects correspond to the new steady states. As Figure 7 in the Appendix shows, the share of the income gap explained by these reforms is fairly robust to the various sensitivity scenarios we perform. See the Appendix for an example calculation of accounting for the gap.

Table 3. Italy: GDP and employment effects of structural reforms

Stylised policy impulse	size		GDP effect (% deviation from baseline)					Employment effect (% deviation from baseline)				
Years			**1**	**2**	**5**	**10**	**long run**	**1**	**2**	**5**	**10**	**long run**
Product market												
Reducing final goods market mark-up	-0.7	pp.	0.1	0.2	0.3	0.4	1.2	0.1	0.2	0.2	0.2	0.5
Reducing intermediate firms' entry barriers	-17.8	pp.	-0.1	-0.1	0.2	0.8	3.7	0.1	0.1	0.1	0.1	0.9
Labour market												
Tax-shift from labour to consumption	-9.2	pp.	0.7	0.7	0.7	1.1	2.2	0.7	1.0	1.4	1.9	2.3
Knowledge and innovation												
R&D subsidy	28.8	pp.	0.0	0.0	-0.2	0.2	0.9	-0.1	0.0	0.1	0.0	-0.1
Decreasing the share of low skilled workers	-33.0	pp.	0.3	0.2	0.1	0.5	15.4	0.3	0.3	0.2	0.5	11.3
Increasing the share of high skilled workers	6.6	pp.	0.0	0.0	0.1	0.3	7.9	0.0	0.0	0.1	0.1	0.8
Total			0.9	1.0	1.3	3.3	31.2	1.1	1.5	2.0	2.8	15.7

Note: % deviations from baseline. GDP per capita in Italy was 74% of the weighted average of the three highest GDP per capita ratios in the euro area in 2012 (Luxemburg, Austria, and the Netherlands). These measures can account for 87% of the current income gap.

Table 4. Portugal: GDP and employment effects of structural reforms

Stylised policy impulse	size		GDP effect (% deviation from baseline)					Employment effect (% deviation from baseline)				
Years			**1**	**2**	**5**	**10**	**long run**	**1**	**2**	**5**	**10**	**long run**
Product market												
Reducing final goods market mark-up	-9.7	pp.	-0.3	0.3	2.8	6.0	14.3	-0.2	0.3	2.0	3.3	5.4
Reducing intermediate firms' entry barriers	-1.9	pp.	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0
Labour market												
Tax-shift from labour to consumption	-8.6	pp.	0.6	0.6	0.5	0.9	1.9	0.5	0.7	0.9	1.4	1.8
Knowledge and innovation												
R&D subsidy*	0	pp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Decreasing the share of low skilled workers	-52.6	pp.	0.2	0.1	0.0	0.7	28.4	0.1	0.1	-0.1	0.1	5.8
Increasing the share of high skilled workers	6.6	pp.	0.0	0.0	0.1	0.2	5.8	0.0	0.0	0.1	0.1	0.4
Total			0.4	1.1	3.5	7.9	50.5	0.5	1.1	2.9	4.8	13.4

Note: % deviations from baseline. GDP per capita in Portugal was 57% of the weighted average of the three highest GDP per capita ratios in the euro area in 2012 (Luxemburg, Austria, and the Netherlands). These measures can account for about 67% of the current income gap.

* Portugal stands above our benchmark R&D subsidy rate (see Figure 4), therefore this measure was not simulated.

Table 5. Spain: GDP and employment effects of structural reforms

Stylised policy impulse	size		GDP effect (% deviation from baseline)					Employment effect (% deviation from baseline)				
Years			**1**	**2**	**5**	**10**	**long run**	**1**	**2**	**5**	**10**	**long run**
Product market												
Reducing final goods market mark-up	-9.7	pp.	-0.3	0.3	2.8	6.1	16.4	-0.2	0.2	1.9	3.1	6.4
Reducing intermediate firms' entry barriers	-4.3	pp.	0.0	0.0	0.0	0.2	0.7	0.1	0.0	0.0	0.0	0.2
Labour market												
Tax-shift from labour to consumption	-12.6	pp.	1.0	1.1	1.0	1.7	3.6	1.0	1.4	1.9	2.6	3.7
Knowledge and innovation												
R&D subsidy	6.5	pp.	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	-0.1
Decreasing the share of low skilled workers	-35.8	pp.	0.2	0.2	0.2	0.5	14.9	0.2	0.2	0.1	0.5	10.1
Increasing the share of high skilled workers	1.0	pp.	0.0	0.0	0.1	0.2	0.3	0.0	0.0	0.1	0.1	-0.4
Total			0.9	1.6	4.1	8.7	36.0	1.0	1.9	4.0	6.3	19.8

Note: % deviations from baseline. GDP per capita in Spain was 73% of the weighted average of the three highest GDP per capita ratios in the euro area in 2012 (Luxemburg, Austria, and the Netherlands). These measures can account for 99% of the current income gap.

6. Comparison with other studies

In this section, we compare results from our model simulations to recent results published by the OECD (Bouis and Duval 2011, Cacciatore et al. 2012) and the IMF (Barkbu et al. 2012, Lusinyan and Muir 2013, and Eble et al. 2013). We compare results both in terms of the reform needs identified by these authors and the estimated quantitative impacts. Most of the differences can be explained by the type of reforms considered in the different studies, with our study focusing on product market, fiscal and skill-enhancing reforms, while other studies look either at different subsets of reforms (e.g. without skill-enhancing reforms) and define the magnitude of the shocks differently.

Bouis and Duval (2011) provides a meta-analysis of the medium- and long-run GDP impacts of structural reform scenarios in the areas of product and labour markets relying on existing OECD empirical studies. The paper considers reforms in continental European countries which close the gap vis-à-vis the best practices of OECD countries. The authors stress reforms in service sectors (network industries and retail) and they identify Greece and Portugal as countries with the largest reform needs in this area. Particularly, aligning product market reforms in upstream sectors on best practice is estimated to have the potential to deliver up to 9 % productivity increase after 10 years. The largest gain could be accrued by Portugal: fast reform implementation could result in 4 % increase after 5 years and close to 9 % after ten years. The OECD obtains slightly smaller effects for Greece. The product market reform scenario draws on econometric estimates of OECD regulatory burden indicators in large non-manufacturing industries that produce important intermediate inputs for the rest of the economy (energy, transport, communication, retail distribution and professional services). These sectors are also part of the final goods sector in our model, therefore our final goods mark-up reduction scenario resembles the product market reform scenario of Bouis and Duval (2011). Despite the differences in the underlying structural indicators, the OECD and our modelling results are of similar order of magnitude over the comparable time horizon.

The OECD study also estimates the effect of reducing the tax wedge on labour, although not in revenue neutral way, i.e. there is no increase in other taxes. The estimated increase in employment rate from labour tax wedge cut is the largest for Greece, almost 3.5 percentage point after 10 years, but almost negligible for Portugal. Our results are somewhat smaller but not directly comparable for three reasons. First, the ranking of countries is different because we do not use the same baseline labour taxes for the analysis[10]. Second, our simulations assume revenue neutral swap between labour and consumption taxes, while the OECD estimates consider full tax-cuts. Finally, we increase the implicit consumption tax rates to the average of the three highest euro area tax rates while in Bouis and Duval (2011) labour tax is reduced to the average labour tax wedge that prevails in six OECD countries with the highest employment rate.

Cacciatore et al. (2012) also offers a DSGE model based analysis of various labour and product market reforms. Although their model is calibrated on aggregate euro area specifications and not on the Southern European member states, the authors also come to the conclusion that the short-run effects of structural reforms are small, similar to our findings. Typically, it takes at least a couple of years for the benefits to materialise with sizable short-run transitional costs, e.g. increase in unemployment. Their simulation results suggest that an ambitious reform package of eliminating the euro area countries' gap with OECD best practices in product and labour market benchmarks (entry barriers, unemployment benefits, job protection) could boost GDP by around 6 percent after 5 years, and by more than 8 percent after 20 years.

Barkbu et al. (2012), an IMF study focusing on structural reforms and growth does not show comparable country specific simulation results to our estimates. Nevertheless, the paper draws similar conclusions with respect to the timing and the importance of structural reforms as our own scenario analysis. Particularly, both the IMF study and our simulation exercises point to the limited short run gains from structural reforms and at the same time emphasize the large potential gains in the medium and long run. Barkbu et al. (2012) lists several reasons why the short run gains of structural reforms are small or ambiguous, e.g. the time lag needed for the reforms to mature over time and the adjustment costs associated with capital and labour mobility. The authors also stress that often the increase in productivity implies a decrease in employment in the short run. In line with our own research, the study shows that over a five year horizon, product market reforms and tax reforms promise the largest economic gains. The results from the IMF's GIMF model (see below) suggest that eliminating half of euro area countries' gap with OECD best practice in labour market and pension policies could boost their GDP on average by almost 1.5 percent after 5 years, and tax and product market reforms by another 1.1 and 2.3 percent respectively.

[10] Our analysis uses the economy wide implicit labour tax rates while in the OECD study the average tax wedge on labour is defined only for the average worker earnings of one-earner married couple with two children.

Two recent IMF working papers utilised the GIMF model for structural reform assessment focusing on Italy and Greece respectively. Lusinyan and Muir (2013) assess Italian structural reforms and show that product market policies equivalent to a 8.75 pp. decline in mark-ups could increase output by 4.4 percent after 5 years and almost 8 percent in the long-run. Our estimates suggest there is less scope for mark-up reductions in Italy. Given smaller product market reform shocks, our results yield lower gains, although proportionally our short-run effects are of the same order of magnitude. Lusinyan and Muir (2013) also show additional reform scenarios, including labour market reforms and fiscal expenditure shifts, which, all combined, raise Italian real GDP by about 8.6 percent after 5 years and almost 22 percent in the long-run. A similar simulation framework is applied in Eble et al. (2013) for Greek structural reforms with sizable potential GDP effects from a combination of product and labour market reforms. Closing roughly half the gap between Greece and the rest of the euro area in selected policy indicators Greek real GDP could increase by around 6.5 percent after a 6 percent decline in mark-ups and by an additional 2.5 percent due to labour market reforms by 2030.

7. Conclusions

This paper has presented an endogenous growth framework for analysing the intertemporal effects of structural reforms. Since many reforms are likely to have effects on TFP such an approach appears warranted. A model-based analysis has the advantage that we can look simultaneously at different structural rigidities. Assessing reform needs in a comprehensive fashion also allows us to assess the plausibility of the individual reform multipliers generated by the model. Closing the reform gap relative to a benchmark country (or aggregate) should roughly close the corresponding income gap. This is the case for Spain, and to a lesser extent for Italy. But for Greece and Portugal the aggregate effects of the reform scenarios cannot close the full income gap, suggesting that there are remaining structural rigidities which we have not quantified here.

In line with other studies from the IMF and OECD, our simulation exercise shows that structural reforms are crucial: they promise large potential economic gains in the medium and long run. However, the short run gains are unlikely to be large. Our analysis includes product market reforms in market competition and deregulation, tax reforms, knowledge and innovation type reforms. Although the latter two types of reforms are not included in the IMF and OECD studies, Barkbu et al. (2012) also emphasizes that pro-growth programs, such as expenditure on education and R&D should be preserved under expenditure cuts, while tax increases should rely on the least growth-distorting instruments. This paper also argues for placing more emphasis on education policy which is the key in upgrading the labour force, especially in the Southern European countries where the share of low skilled labour is among the highest in the euro area. Increasing the share of medium and high-skilled human capital promises significant long-run economic gains in these countries.

Appendix

We checked the robustness of the results with respect to the elasticity of substitution between skills (μ) , changing wage-premium ratios, which are crucial to determine the skill-efficiencies, the Frisch labour-supply elasticity $((1-L_t)/(\kappa L_t))$ and the ratio of elasticity between domestic and foreign stock of knowledge in the knowledge production function (ϕ and ϖ). The following tables compare the central scenario (S0) with five alternative scenarios: (S1) decreasing the elasticity of substitution between skill groups to μ=1.4 as estimated by Katz and Murphy (1992); (S2) imposing an occupational based wage-premium[11] (S3) increasing wage premiums for high and medium-skilled unilaterally by 10pp.; (S4) imposing 10 pp. lower Frisch labour supply elasticity (from 0.4 to 0.3) which is closer to the lower bound of the estimates in the literature (Chetty, 2012), and finally by increasing the weight of foreign intangible capital relative to domestic one by 10% in the R&D production function (scenario S5). The simulations suggest that under the empirically plausible range of the elasticity of substitution between skill-groups, alternative wage-premium definitions, the elasticity of labour supply, and higher domestic knowledge elasticities, our results are fairly robust (see Tables 6-9). The driving forces behind the sensitivity scenarios are the following. Decreasing the elasticity of substitution between skill-types weakens the long-run GDP effect from shifting the share of labour force from low to medium skilled, but strengthens the effect of shifting labour skills from medium to high-skilled. The reason is that lower substitution possibilities make a skill-shift less effective since the excess labour skill is less readily employable. Naturally, this is less of a limiting factor in case of increasing the share of high-skilled since the excess supply of high-skilled can be also be employed in the R&D sector as opposed to the medium-skilled workers which are only employable in the final goods sector. A high-skilled biased shift therefore can further increase productivity and final output in this scenario. The effect of alternative wage-premium settings is more direct: the higher the wage-premium, the higher is the implied efficiency of the higher skilled labour force, therefore increasing its share will further benefit the economy. Intuitively, the first three sensitivity scenarios mainly affect the skills upgrading scenarios. Our next sensitivity scenario, lowering the Frisch elasticity has the strongest effect on the tax-shift reforms because it lowers the responsiveness of labour-supply w.r.t. changes in after-tax labour income, which is a crucial explanatory factor behind the positive output and employment effect of shifting the burden of taxation from labour to consumption. Our last sensitivity scenario has its largest influence on the achievable gains from R&D subsidies. Countries with higher dependence on foreign R&D spillovers experience somewhat less positive GDP gains from increasing R&D subsidies. As Figure 7 shows, the share of the income gap explained by the reform measures is fairly robust to the various sensitivity scenarios.

[11] In this calibration, high-skilled wages are approximated by the annual earnings of scientists and engineers defined as employees working as professionals or associate professionals in physical, mathematical, engineering, life science or health occupations (ISCO-08 occupations 21, 22, 31, 32) irrespective of their educational attainment. Annual earnings of non-science and engineering employees working in high-skilled or skilled occupations were taken as proxies for the medium-skilled and finally, low-skilled wages are accounted as earnings of employees working in elementary occupations, in all of these cases irrespective of their educational attainment.

Table 6. Sensitivity analysis of long-run GDP effects: Greece

	Central scenario	μ=1.4	Wage-premiums defined by occupations	10 pp. higher wage-premiums for medium and high-skilled	Lower Frisch elasticity	10% higher foreign/domestic knowledge elasticity ratio
Scenario	(S0)	(S1)	(S2)	(S3)	(S4)	(S5)
Product market						
Reducing final goods market mark-up	39.3	39.2	39.2	39.1	36.3	39.0
Reducing intermediate firms' entry barriers	7.9	7.8	7.9	7.8	7.5	7.2
Labour market						
Tax-shift from labour to consumption	4.5	4.5	4.4	4.4	3.5	4.5
Knowledge and innovation						
R&D subsidy	1.4	1.4	1.4	1.4	1.5	1.3
Decreasing the share of low skilled workers	3.8	3.4	6.3	5.0	4.1	3.8
Increasing the share of high skilled workers	3.9	4.2	3.8	4.4	4.0	3.8
Total	60.8	60.5	63.0	62.2	56.7	59.5

Note: in our baseline setting wage premium for high-skilled and medium-skilled were 34.4% and 16.4% respectively. In the occupational based classification the corresponding wage premia are 29% and 36.5% which explains the almost twice as large long-run GDP effect of increasing the share of medium-skilled and the slight decline for the simulation results in case of the skill shift towards high-skilled.

Table 7. Sensitivity analysis of long-run GDP effects: Italy

	Central scenario	μ=1.4	Wage-premiums defined by occupations	10 pp. higher wage-premiums for medium and high-skilled	Lower Frisch elasticity	10% higher foreign/domestic knowledge elasticity ratio
Scenario	(S0)	(S1)	(S2)	(S3)	(S4)	(S5)
Product market						
Reducing final goods market mark-up	1.2	1.1	1.2	1.1	1.0	1.1
Reducing intermediate firms' entry barriers	3.7	3.6	3.7	3.7	3.5	3.4
Labour market						
Tax-shift from labour to consumption	2.2	2.1	2.2	2.1	1.7	2.1
Knowledge and innovation						
R&D subsidy	0.9	0.9	0.9	0.9	0.9	0.8
Decreasing the share of low skilled workers	15.4	15.0	15.4	16.6	15.5	15.3
Increasing the share of high skilled workers	7.9	8.4	6.8	8.7	8.2	7.6
Total	31.2	31.2	30.2	33.1	30.9	30.5

Note: in our baseline setting wage premium for high-skilled and medium-skilled were 54.7% and 38.2% respectively. In the occupational based classification the corresponding wage premia are 36% and 37.5% which explains the smaller long-run GDP gains from the scenario of increasing the share of high-skilled.

Table 8. Sensitivity analysis of long-run GDP effects: Portugal

	Central scenario	μ=1.4	Wage-premiums defined by occupations	10 pp. higher wage-premiums for medium and high-skilled	Lower Frisch elasticity	10% higher foreign/domestic knowledge elasticity ratio
Scenario	(S0)	(S1)	(S2)	(S3)	(S4)	(S5)
Product market						
Reducing final goods market mark-up	14.3	14.3	14.4	14.3	13.0	14.3
Reducing intermediate firms' entry barriers	0.2	0.2	0.2	0.2	0.2	0.2
Labour market						
Tax-shift from labour to consumption	1.9	1.9	1.9	1.9	1.4	1.9
Knowledge and innovation						
R&D subsidy*	0.0	0.0	0.0	0.0	0.0	0.0
Decreasing the share of low skilled workers	28.4	26.6	23.7	29.9	30.7	28.3
Increasing the share of high skilled workers	5.8	5.9	7.0	6.5	6.0	5.3
Total	50.5	49.0	47.2	52.7	51.2	50.0

Note: in our baseline setting wage premium for high-skilled and medium-skilled were 35.8% and 94.7% respectively. In the occupational based classification the corresponding wage premia are 57% and 72.4% which explains the larger long-run GDP gains from the shift towards high-skilled and the smaller gains from the skill-shift towards medium-skilled respectively.

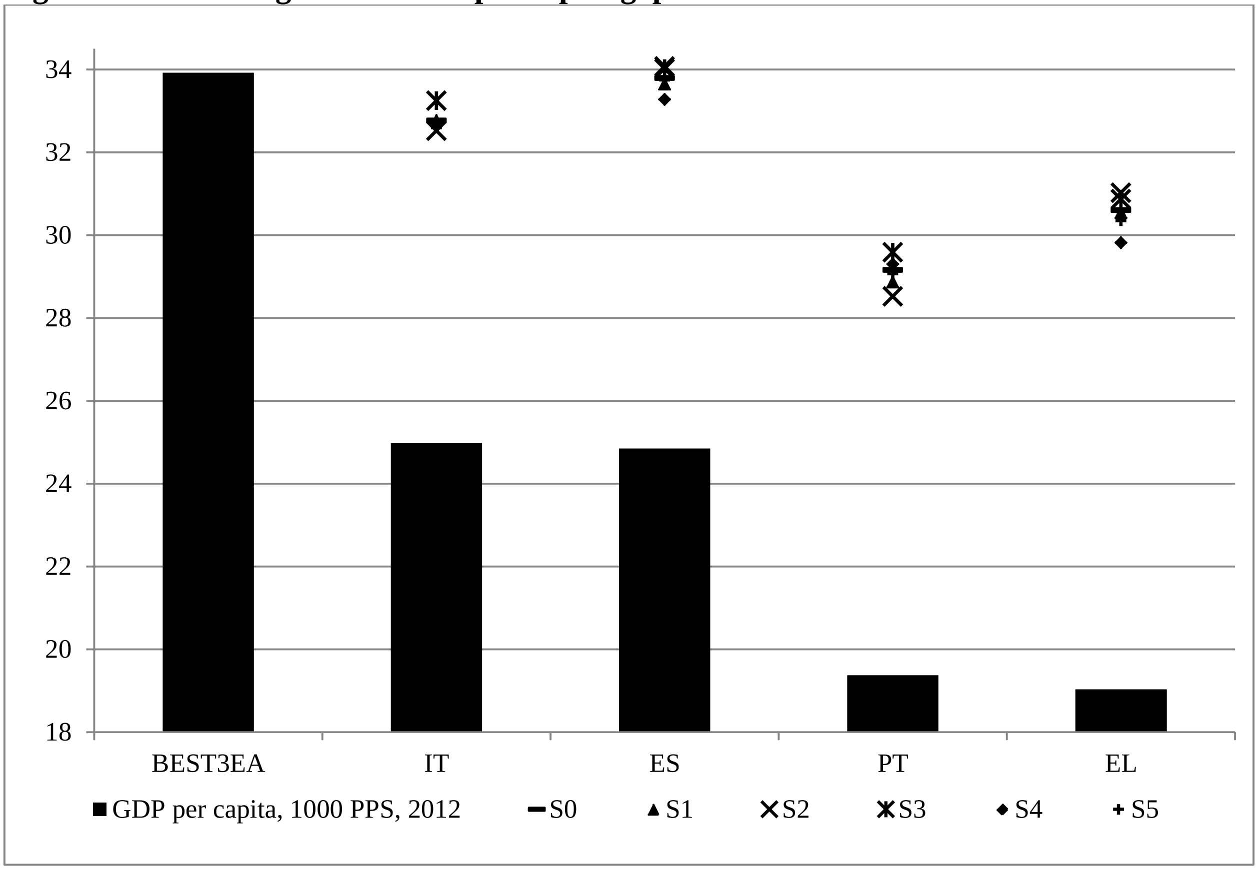
* Portugal stands above our benchmark R&D subsidy rate (see Figure 4), therefore this measure was not simulated.

Table 9. Sensitivity analysis of long-run GDP effects: Spain

	Central scenario	μ=1.4	Wage-premiums defined by occupations	10 pp. higher wage-premiums for medium and high-skilled	Lower Frisch elasticity	10% higher foreign/domestic knowledge elasticity ratio
Scenario	(S0)	(S1)	(S2)	(S3)	(S4)	(S5)
Product market						
Reducing final goods market mark-up	16.4	16.3	16.2	16.2	14.7	16.3
Reducing intermediate firms' entry barriers	0.7	0.7	0.7	0.7	0.7	0.7
Labour market						
Tax-shift from labour to consumption	3.6	3.6	3.5	3.5	2.7	3.6
Knowledge and innovation						
R&D subsidy	0.1	0.1	0.1	0.1	0.1	0.1
Decreasing the share of low skilled workers	14.9	14.3	16.1	15.9	15.2	14.8
Increasing the share of high skilled workers	0.3	0.4	0.4	0.5	0.5	0.3
Total	36.0	35.4	37.1	36.9	33.9	35.8

Note: in our baseline setting wage premium for high-skilled and medium-skilled were 37.2% and 38.1% respectively. In the occupational based classification the corresponding wage premia are 45% and 49.5% which explains the larger long-run GDP gains from the skill-composition scenarios. This gain is of course less pronounced in case of increasing the high-skilled share, where Spain is actually one of the best euro area performers.

Figure 7. Accounting for the GDP per capita gap



Note: The figure shows that the new steady state GDP levels under the different scenarios could account for a substantial part of the existing GDP per capita gap between the average of the best three euro area countries and the Southern member states. We take the difference between the projected and the current (2012) GDP per capita by multiplying the total output effect of our country specific growth rates with the current GDP per capita values and divide it by the current GDP per capita gap. E.g. the weighted average of the best three euro area GDP per capita figures was 33.921 PPS in 2012 (Luxembourg, Austria, Netherlands), therefore for Spain the corresponding ratio is: (24.850·0.36)/(33.921-24.850)=0.986. Note that this calculation serves as an illustration for the large potential gains of these reforms expressed in terms of the current GDP per capita gap, it does not take into account that in the future, GDP per capita will be higher for the best three euro area countries as well.

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