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Stagnant Wages, Sectoral Misallocation and Slowing Productivity Growth

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Abstract

I propose a two-sector endogenous growth model with heterogeneous sectoral productivity and sector-specific, nonlinear hiring costs to analyse the link between sectoral resource allocation, low productivity growth and stagnant real wages. My results suggest that an upward shift in the labor supply, triggered for instance by a labor market reform, as among others implemented in Germany in 2003-2005, is beneficial in the long-run as it raises growth of technology, labor productivity and real wages. I show, however, that in the immediate phase following the labor supply shock, labor productivity and real wages stagnate as employment gains are initially disproportionally allocated to low-productivity sectors, limiting the capacity for technology growth and depressing real wages and productivity. I demonstrate that due to the learning-by-doing growth externality in the high-productivity sector the competitive equilibrium is inefficient as firms fail to internalize the effect of their labor allocation on aggregate growth. Subsidies to high-productivity sector production can alleviate welfare losses along the transition path.

JEL codes: E20, E24, E60, O40, O41

Keywords: Subdued Wage Growth, Productivity Slowdown, Misallocation, Endogenous Productivity Dynamics, Labor Market Policies

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1 Introduction

In recent years, many advanced economies have experienced a sustained slowdown in productivity growth, which has generally set in already in the early 2000s and has gained particular attention in the years following the Great Recession. Additionally, the persistently sluggish wage development in many advanced economies has represented a phenomenon central to the policy discussion and has widely prevailed even in the context of falling unemployment. Simultaneously, several of these economies experienced a sustained upward shift in employment, triggered by means of two major channels. On the one side, labor market policies aimed at raising aggregate employment were an important driving force. The large-scale labor market reforms implemented in Germany from 2003 to 2005, the so-called "Hartz" reforms, constitute a prominent example in this context. In other countries, in turn, migration can be considered the main driver of the employment shift. In this context, the experience of the United Kingdom, characterized by a pronounced productivity slowdown, stagnant real wage growth, rising employment and simultaneous significant net migration, is particularly notable.[1]

This paper draws on the experience of a simultaneous stagnant wage development and slowing productivity growth in the presence of pronounced employment expansions and proposes an at this stage unexploited, misallocation-based mechanism which rationalizes these observations in a tractable macroeconomic framework. Most studies on the effect of the German labor market reforms focus on the direct labor market impact (see Fahr and Sunde (2009) and Klinger and Rothe (2012) for reference). Theoretical studies on the macroeconomic level are scarce and study the effect on unemployment and welfare in a search-and-matching context (Krause and Uhlig (2012); Krebs and Scheffel(2013)) or analyze the build-up of current account imbalances in this context (see for instance Kollmann et al. (2015); Hochmuth, Moyen and Stähler (2018)). The effect of large-scale employment shifts on the evolution of technology growth and aggregate productivity, by contrast, has at this stage been overlooked by the existing literature. Against this background, this paper takes a novel perspective on the issue and addresses the impact of an employment expansion from a macroeconomic, endogenous growth perspective and analyses the effect on technology growth and hence the economy's long-run growth rate. Moreover, to my knowledge, this is the first analysis, which studies the effect of these employment shifts on the allocation of production factors and explores the role of misallo-

[1] While the case of Germany represents a clear-cut example of a large-scale labor market reform and stands thus in the focus of this analysis, several further countries have implemented similar labor market reforms focused on raising the labor supply, with Sweden and Denmark as noteworthy examples. Moreover, further euro area economies implemented labor market reforms following the Great Recession and euro area debt crisis.

cation in this setting. Taking this approach also permits to disentangle dynamics over the short- to medium-term from long-run effects, as well as to theoretically demonstrate the interaction between the employment shift, real wage growth and the evolution of productivity over various horizons. This paper further provides a welfare analysis and derives optimal policies to accompany the employment shift in order to alleviate welfare losses alongside the transition path.

As to the theoretical model specification, the framework entails a tractable mechanism, which demonstrates that both the phenomenon of stagnant wage and productivity growth can be the result of a misallocation of production factors to low-productivity sectors following a positive shock to employment. For that purpose, I construct a two-sector endogenous growth model with heterogeneous productivity across sectors, where technology advances are concentrated in the high-productivity sector, which constitutes the growth engine in the economy. More specifically, the model is subject to an endogenous total factor productivity mechanism of the learning-by-doing type in which technology growth is increasing in the labor allocated to the high-growth sector. Labor is generally homogeneous and mobile. However, nonlinear labor adjustment costs in the high-productivity sector represent a constraint to the instantaneous flow of labor to the high-productivity sector. These adjustment costs only occur in the case of hiring, reflecting the costs from initial training, learning of complex production processes and the adjustment of human capital to the production requirements in this sector.

I demonstrate that exogenous upward shifts in employment generally exert a positive effect on aggregate economic performance over the long-run since they increase the rates of both technology and productivity growth and also foster real wage growth. My analysis further shows, however, that over the short- to medium-term labor productivity and real wages stagnate. The underlying cause is that employment gains are at first disproportionately realized in the low-productivity sector, causing a transitory misallocation of productive resources, which temporarily depresses labor productivity and real wage growth. Over time, however, the high-productivity sector realizes employment gains and the initial extent of misallocation is reversed. I demonstrate that due to the presence of a growth externality resulting from the learning-by-doing process in the high-productivity sector, the competitive allocation is inefficient. The cause of the inefficiency is that firms in the high-productivity sector do not internalize the impact of their own hiring choices on the aggregate growth performance. These inefficiencies in the decentralized economy give a role for policy intervention: Subsidizing production in the high-productivity sector is an effective policy tool to reduce the initial extent of misallocation following the employment shock and thus an adequate policy measure to reduce welfare losses occurring along the transition to the new equilibrium. This finding emphasizes the importance of not only the quantity but also the quality of employment in evaluating the recent slowdown in productivity and real wage growth.

This paper relates to the literature on natural resource misallocation, commonly referred to as "the Dutch disease" (Corden and Neary (1982)). These studies focus on the adverse effect, which the discovery of natural resources can exert on economic performance and welfare.[2] A subset of these papers, such as Krugman (1987) and Matsuyama, (1992) model growth in the form of learning-by-doing, as does this paper. In my framework, however, it is the abundance of the production factor labor which triggers the misallocation towards stagnant sectors. That given, this paper is also tightly connected to the cost disease in the service sector, the so-called "Baumol disease", as the latter also addresses the role of relative labor allocation across sectors, which are heterogeneous in productivity, on the performance of the aggregate economy (see Baumol and Bowen (1966) and Baumol (1967) for reference). The model I present features an episode in which the Baumol disease mechanism of the misallocation of labor to stagnant sectors is active. However, the channel inducing the stagnation of labor productivity and wage growth in my framework differs from typical Baumol disease models as a sudden expansion in employment constitutes the trigger in my framework. Lastly, a closely related research area studies misallocation in the context of the recent productivity slowdown. The misallocation in several euro area countries upon monetary union and interest rate convergence and the resulting misallocation of capital flows to low-productivity sectors constitutes a major field addressed by recent research (see Benigno and Fornaro (2014), Benigno, Converse and Fornaro (2015) and Gopinath et al. (2017)). In contrast to these studies, this paper does not focus on the role of low interest rates and large capital inflows as a trigger of sectoral misallocation but instead proposes a new channel for a misallocation-induced productivity slowdown. More specifically, the central mechanism in my framework originates from the presence of the endogeneity of the labor supply decision and misallocation in my frameworks results from an abundance of the production factor labor.

The outline of this paper can be summarized as follows. Section 2 discusses stylized facts on the issue of stagnant productivity and wage growth following employment shifts. Section 3 demonstrates the model framework and hence the basis of this analysis. Subsequently, I present the results for the evolution of real wages as well as technology and labor productivity growth over both the short- to medium-term and in the long-run (section 4). Section 5 points out the inefficiencies in the competitive allocation by deriving

[2]See Frankel (2011) and Van der Ploeg (2011) for a review of this strand of the literature.

the differences vis-à-vis the social planner equilibrium. Based on these findings, section 6 presents the corresponding implications and options for policy making in this context. Lastly, section 7 concludes.

2 Stylized facts

This section presents stylized facts on productivity growth, the evolution of real wages and employment shifts, with a special focus on the experience of Germany following its large-scale labor market reform. Figure 1 illustrates developments in Germany with regards to productivity, wages and employment over roughly the past three decades. A central observation in this context is that, after a phase of both relatively high labor productivity and real wage growth in the beginning of the sample, from the early 2000s onward both labor productivity and real wage growth began to stagnate for a sustained time period. This substantial slowdown in both productivity and real wage development illustrates also the flattening of the corresponding trend over the 2003 to 2012 period (orange line) vis-à-vis the pre-reform trend (blue line). Importantly, this episode overlaps with a large-scale labor market reform package, commonly referred to as the "Hartz" reforms, which was implemented from 2003 to 2005, and constitutes the largest change in the German social security system in the post-war period (for an overview of the main reform steps and labor market effects see, for instance, Jacobi and Kluve (2007) and Schmöller (2013)). A central aim of the Hartz reforms was to raise employment, induced above all by a substantial decrease of workers' outside option through a marked reduction of both unemployment benefit payments and entitlement periods. In addition, benefits were rendered conditional on proven active job search, severe penalties in case of non-compliance were introduced and the acceptance of suitable job offers was made mandatory. A further important reform step constituted the introduction of new employment forms with shorter standard weekly working hours to foster outflows of unemployment and inactivity into employment.

These events translated into a large-scale shift in the evolution of employment in the follow-up of the reforms in the mid 2000s (see Figure 1, lower-left panel): Upon a phase of persistently high unemployment, employment increased rapidly and continuously over the the post-reform period. The employment level in 2013 exceeded its 2003 counterpart by roughly 9 per cent and has expanded further in the context of the economic expansion in Germany. Interestingly though, these large-scale employment gains have not been evenly distributed across sectors. Instead, employment increases were mostly realized in sectors with relatively low productivity, while employment in high-productivity sectors

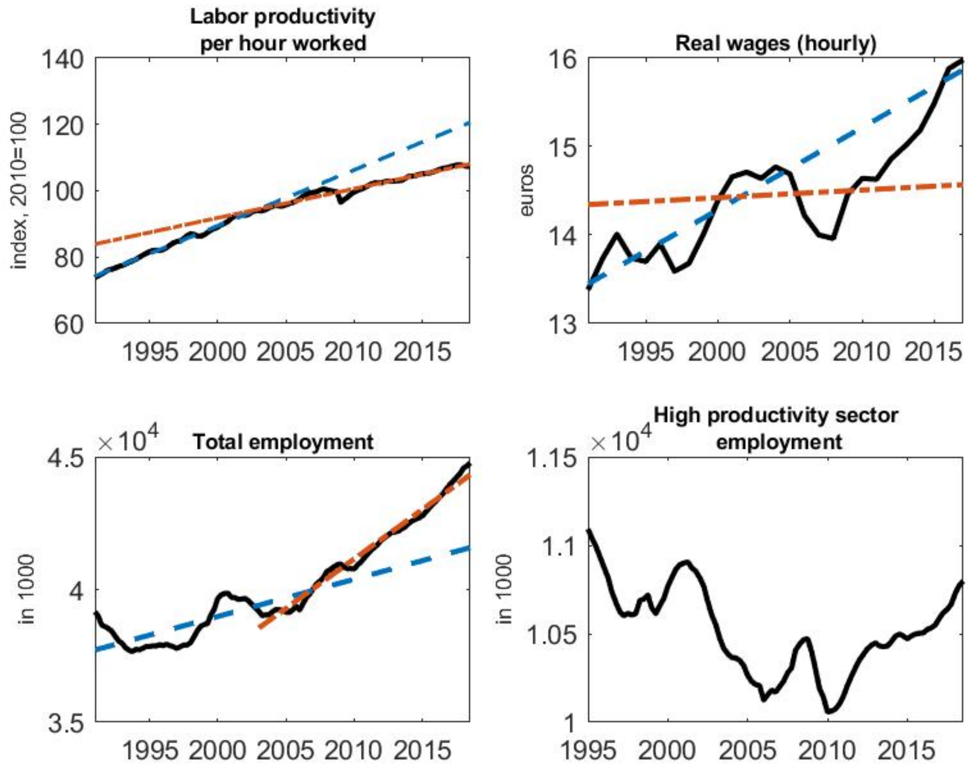

Figure 1: Evolution of productivity, wages and employment in Germany
Upper-left panel: real labor productivity per hour worked, index (2010=100), quarterly and seasonally-adjusted data, source: Eurostat; upper-right panel: real earnings per employee hour worked, net, constant prices, resident concept, in euros, source: German Federal Statistical Office; lower-left panel: total employment, measured in 1000 workers, age: 15-64, source: Eurostat; lower-right panel: employment in high-productivity sectors (defined as industry (excluding construction), information and communication as well as financial and insurance services), measured in 1000 workers; blue and orange lines indicate linear trends evaluated over the time period 1991q1 to 2002q4 and 2003q1 to 2012q4 respectively.

stagnated following the labor market reform and only started to increase towards the end of the sample period, as also illustrated in the lower-right panel of Figure 1. In sum, the experience in Germany has been characterized by stagnant real wage growth, a slowdown in productivity, as well as a substantial expansion of employment, which was disproportionally concentrated in low-productivity sectors. This paper draws on this experience and proposes a model which reconciles these observations into a single, tractable theoretical framework. In particular, I propose a mechanism, which demonstrates that a slowdown in productivity and stagnant real wage growth despite substantial decreases in unemployment can constitute two sides of the same coin following an employment expansion as in the initial phase following the employment shock, production factors are misallocated to low-productivity sectors.

While the case of Germany constitutes a clear-cut example of a large-scale expansion of employment triggered by a labor market reform and thus represents an important empirical motivating episode of the theoretical mechanism proposed in this paper, the insights of this analysis are not restricted to the case of Germany. Firstly, many countries have implemented comparable labor market reforms. Denmark and Sweden constitute notable examples. Moreover, several euro area economies implemented similar labor market policies following the recent crises in the euro area . While the focus of this analysis is the labor market policy-induced employment shifts with economic dynamics in Germany during the post-reform phase as a concrete example, a further potential channel can be found in migration, with the UK economy as a potential suitable example in this context: Also the UK experienced a pronounced expansion in employment, while simultaneously labor productivity growth has markedly slowed and real wages have stagnated over a sustained time period.

3 The model

We consider a perfect foresight, infinite horizon, closed economy. Let time be discrete and indicated by t. The model economy is inhabited by a continuum of mass 1 of identical households, as well as a large number of identical firms. Production takes place in two sectors, which are heterogeneous with regards to productivity: The economy features a a low-productivity sector as well as a high-productivity sector, which constitutes the growth engine in the economy.

3.1 Households

The representative household derives utility from consumption C_t and leisure $1-L_t$, where θ_t denotes the preference parameter of leisure as opposed to consumption.[3] Consumption C_t is a Cobb-Douglas aggregate of the good produced in sectors h and l respectively:

$$C_t = (C_t^h)^{\omega}(C_t^l)^{1-\omega}, \tag{1}$$

where ω states the weight of the good in the high productivity sector ($0 < \omega < 1$). Households choose consumption of both goods C_t^h and C_t^l, labor input L_t, as well as bond holdings B_{t+1} to maximize lifetime utility

$$\max_{C_t^h, C_t^l, L_t, B_{t+1}} \sum_{t=0}^{\infty} \beta^t \left(log(C_t) + \theta_t log\left(1 - L_t\right)\right), \tag{2}$$

subject to the budget constraint

$$C_t^h + P_t^l C_t^l + \frac{B_{t+1}}{R_t} = W_t L_t + B_t + \Pi_t, \tag{3}$$

where $0 < \beta < 1$ denotes the subjective discount factor. P_t^l stands for the relative price of good l in terms of units of good h, the price of which is normalized to unity. Further, R_t represents the real interest rate and W_t the real wage expressed in good h units. B_{t+1} refers to the stock of one-period risk-free bonds, bought at the price $\frac{1}{R_t}$. We abstract from corner solutions and focus on equilibria in which production occurs in both sectors. Labor is perfectly mobile and wages equalize across sectors ($W_t^h = W_t^l = W_t$). Hence, $W_t L_t$ refers to the household's time t labor income. Firms are owned by the representative

[3]Preferences are logarithmic, additive and separable in consumption and leisure as, for example, in King, Plosser and Rebelo (1989). The logarithmic structure of the preferences ensures the existence of a balanced growth path.

household, which earns the corresponding firm profits Π_t.

The set of first order conditions can be derived as follows. The intratemporal condition links the relative price P_t^l to the marginal rate of substitution between good h and l respectively:

$$P_t^l = \frac{1-\omega}{\omega} \frac{C_t^h}{C_t^l}. \tag{4}$$

The Euler equation, denoted in terms of C_t^h units, determines the intertemporal allocation of the consumption of the good produced in the high-productivity sector and can be derived as

$$\frac{1}{C_t^h} = \beta R_t \frac{1}{C_{t+1}^h}. \tag{5}$$

Moreover, the trade-off between consumption and leisure can be stated as follows:

$$\frac{\theta_t}{1-L_t} = \frac{\omega}{C_t^h} W_t. \tag{6}$$

3.2 Production: Low-productivity sector

Contrary to sector h (see section 3.3), no technological innovations are realized in the low-productivity sector l. This assumption captures the notion of sector h representing the growth engine in the economy, while at the same time keeping the model tractable.[4] The non-tradable good is produced using labor by means of the production function

$$Y_t^l = L_t^l. \tag{7}$$

Perfectly competitive firms in sector l choose labor input L_t^l to maximize profits

$$\max_{L_t^l} P_t^l Y_t^l - W_t L_t^l, \tag{8}$$

delivering the optimality condition

$$P_t^l = W_t. \tag{9}$$

[4]For simplicity, I abstract from technological innovation in the low-productivity sector. However, the key model implications would be qualitatively unaltered when allowing for productivity advances in both sectors, while the learning-by-doing externality is more pronounced in the high-productivity sector.

3.3 Production: High-productivity sector

Firms in the high-productivity sector produce good h using labor input L_t^h and building on the stock of knowledge A_t according to the production function

$$Y_t^h = A_t \left(L_t^h\right)^{1-\alpha}, \tag{10}$$

where $0 < \alpha < 1$ and A_t is non-rival and non-excludable.[5] Sector h can be considered the economy's growth engine as the evolution of knowledge A_t determines technological progress, which constitutes the main driver of long-run growth in the economy. The costs of production in sector h consist of wage costs $W_t L_t^h$ as well as nonlinear hiring costs given by

$$A_t \quad \frac{\psi}{2} \left(\frac{\Delta L_t^h}{L_{t-1}^h}\right)^2 L_{t-1}^h \quad \mathbf{I}\left(\Delta L_t^h\right), \tag{11}$$

where

$$\mathbf{I}\left(\Delta L_t^h\right) = \begin{cases} 1, & \text{if} \quad \Delta L_t^h > 0 \\ 0, & \text{otherwise} \end{cases} \tag{12}$$

and $\Delta L_t^h = L_t^h - L_{t-1}^h$ applies. The basic process describing the hiring costs is quadratic and standard as assumed in the literature on the adjustment cost of production factors. As described in equation, the indicator function $\mathbf{I}\left(\Delta L_t^h\right)$ equals unity in case of hiring $(L_t^h > L_{t-1}^h)$ and zero otherwise, implying that labor adjustment costs are nonlinear and only occur in the case of hiring. Due to this property and the absence of adjustment costs in the low-productivity sector, this specification also implies that labor can be hired freely into sector l, while hiring in the high-productivity sector is subject to costs. This property captures the notion that processes in the low-productivity sector l are compared to the high-productivity sector rather simplistic, rendering introducing newly hired workers in this sector to their tasks rapid and the training costs of new hires vis-à-vis the high-productivity sector negligible. Hiring in sector h, in turn, is costly, given the more complex production processes and correspondingly higher training costs of new hires. Put differently, the prevalence of hiring costs in the high-productivity sector can also be interpreted as a tractable approximation of the presence of search and matching frictions in the economy, thus reflecting the relatively higher search costs in the high-productivity sector. ψ denotes a standard labor adjustment cost parameter. Hiring costs are indexed to the overall total factor productivity level in this sector A_t, which ensures

[5] This type of production function can be considered standard in macroeconomics, see for instance Galí (2008). Decreasing returns to scale can generally also be rationalized by a required managerial capital $\bar{H}$ in high-productivity production, resulting from the complexity of the production structure and the management of human and knowledge capital: $Y_t^h = A_t \bar{H}^\alpha L_t^{h\,1-\alpha}$. See, for instance, Lucas (1978) and Guner et al. (2019) for reference in this context.

that the adjustment costs do not diminish as opposed to the wage costs given that real wages grow at the overall growth rate of the economy on the balanced growth path. In this setting, firms maximize profits by choosing the optimal labor allocation L_t^h:

$$\max_{L_t^h} A_t \left(L_t^h\right)^{1-\alpha} - W_t L_t^h - A_t \frac{\psi}{2} \left(\frac{\Delta L_t^h}{L_{t-1}^h}\right)^2 L_{t-1}^h \mathbf{I}\left(\Delta L_t^h\right). \tag{13}$$

The corresponding optimality condition equals to

$$(1-\alpha) A_t \left(L_t^h\right)^{-\alpha} - A_t \psi \left(\frac{\Delta L_t^h}{L_{t-1}^h}\right) \mathbf{I}\left(\Delta L_t^H\right) = W_t. \tag{14}$$

Since in the steady state the labor allocation in sector h is constant, there are no adjustment costs on the balanced growth path ($\mathbf{I}\left(\Delta \bar{L}_t^h\right) = 0$). Hence, the optimality condition in the new steady state corresponds to $(1-\alpha)\left(\bar{L}^H\right)^{-\alpha} = \frac{\bar{W}_t}{\bar{A}_t}$.

3.4 Evolution of technology growth

The model economy is subject to endogenous growth in the stock of knowledge in sector h, implying the notion that sector h constitutes the growth engine in the economy. The underlying process of knowledge accumulation is of the form of learning-by-doing in the sense that technological progress is increasing in labor allocated to the high-productivity sector L_t^h. More specifically, the stock of knowledge A_t evolves according to the process

$$A_{t+1} = A_t \left(1 + \epsilon L_t^h d_t^\kappa\right), \tag{15}$$

where $d_t = \frac{\bar{L}^h}{L_t^h}$ denotes the distance of the current labor allocation to the respective sector h employment on the balanced growth path $\bar{L}^h$. Hence, tomorrow's technology stock A_{t+1} depends positively on the current technology stock A_t and sector h labor L_t^h reflecting the fact that human capital is required for knowledge creation following Benigno and Fornaro (2014) and Alberola and Benigno (2017). The parameter ϵ captures the efficiency of sector h in knowledge accumulation ($\epsilon > 0$). Technology growth is moreover the higher, the larger the distance d_t to the labor allocation at the balanced growth path and hence the productivity frontier. This property increases the realism of the growth process by departing from a purely linear specification. Instead, the process of knowledge accumulation takes into account that any unit L_t^h can generate higher productivity advances when the labor allocation to the high-productivity sector is below its steady state value and the economy is catching up to its steady state. This assumption captures the notion that in this environment, any unit of labor allocated to sector h increases the technology stock more intensely than in an environment of relatively higher productivity. This features also the property of diminishing returns in the technological progress through R&D, as is in line with the empirical endogenous growth literature (see Griliches, 1990), stating that realizing technology advances becomes increasingly difficult when labor allocated to the innovative sector is already high. κ represents the weight of the distance to the productivity frontier, where $0 < \kappa < 1$ applies. From equation (15), the rate of technology growth g_{t+1} can be derived as

$$g_{t+1} = \frac{A_{t+1}}{A_t} = \epsilon L_t^h d_t^\kappa. \tag{16}$$

At the balanced growth path, the economy's rate of technology growth corresponds to $\bar{g} = \epsilon \bar{L}^h$, which implies that the long-run growth rate of the economy is increasing in the steady state labor allocation to the high-productivity sector, reflecting the need of productive resources in realizing technology advances.

Importantly, and as demonstrated in detail in section (5.2), the knowledge accumulation process (15) generates a growth externality in the economy. Recall that the stock of knowledge is non-rival and non-excludable, which implies in combination with the presence of a large number of firms in the high-productivity sector that firms do not internalize the impact of their own labor allocation on the evolution of the economy's stock of knowledge. This property constitutes a growth externality since sector h firms do not internalize the social value of the labor allocated to the high-productivity sectors in raising technology growth, aggregate productivity and output and thus the overall performance of the aggregate economy.

3.5 Competitive equilibrium

The equilibrium conditions in the competitive equilibrium can be summarized as follows. Good markets for both good h and l have to clear:

$$C_t^h = Y_t^h, \tag{17}$$

$$C_t^l = Y_t^l. \tag{18}$$

As we consider a closed economy, bonds have to be in zero net supply:

$$B_t = 0. \tag{19}$$

Lastly, households' labor supply must be equal to the labor demand by firms:

$$L_t = L_t^h + L_t^l. \tag{20}$$

Hence, the perfect foresight equilibrium[6] can be defined as a set of prices $\{P_t^l, W_t\}_{t=0}^{\infty}$, the allocation $\{Y_t^h, Y_t^l, L_t, L_t^h, L_t^l, C_t^h, C_t^l,\}_{t=0}^{\infty}$ and productivity level $\{A_{t+1}\}_{t=0}^{\infty}$ satisfying equation (4)-(7), (9), (10), (15), (17), (18) and (20).

3.6 Calibration

This section presents the calibration of the model (Table 1). The model is calibrated to annual frequency and the discount factor β is calibrated accordingly ($\beta = 0.975$). I calibrate the scale parameter in high-productivity production α to $\frac{1}{3}$, as standard in the literature (see, for instance, Galí (2008)). The Cobb-Douglas aggregation parameter ω is set to 0.32 to generate a steady state share of high-productivity to total employment $\frac{\bar{L^h}}{\bar{L}}$ of 0.24 - a value consistent with the share of high-productivity sector employment in Germany since the reunification.[7] Disutility of labor θ equals to 2.0146 in the initial state of the economy and to 1.7867 following the labor supply shock, generating overall employment levels of initially $\bar{L_1} = 0.3072$ and $\bar{L_2} = \frac{1}{3}$ in the post-shock phase.[8] The efficiency of labor in the knowledge accumulation process ϵ is set to match an initial growth rate $\bar{g_1}$of 1.47% and is hence in line with the average growth rate of the German economy over the post-reunification period up until the implementation of the large-scale labor market reforms in 2003. The hiring cost parameter ψ is set to a rather low value. To see that this holds true, consider the hiring costs in the case if high-productivity firms were immediately to fully increase employment in their sector to the new steady state value $\bar{L_2^h}$, then the hiring costs would correspond to roughly one per cent of the wage bill in that sector. The parameter κ governs the relative weight of the distance of current labor allocation L_t^h to its steady state value and is set to 0.4. Further, given the other model parameters, the parameters ψ and κ jointly control the speed of the transition to the new steady state which corresponds to roughly 10 years in this setting.

[6]The underlying assumption on the nature of the labor supply shock is that it constitutes a one-time, unanticipated shock ("MIT shock").

[7]I define "high-productivity sectors" as industry (excluding construction), information and communication, as well as financial and insurance services.

[8]This value corresponds to an employment expansion of roughly 9 per cent in the course of the ten year transition to the new long-run equilibrium, which corresponds to the employment increase realized in Germany in the time period 2003 to 2013.

Parameter	Description	Value
β	Discount factor	0.975
α	Production function parameter	$\frac{1}{3}$
ω	Cobb-Douglas parameter (high-productivity sector)	0.32
ψ	Adjustment cost parameter	2.75
θ_1	Initial disutility of labor	2.0146
θ_2	Post-shock disutility of labor	1.7867
ϵ	Efficiency parameter in knowledge accumulation	0.2
κ	Weight of distance in knowledge accumulation	0.4

Table 1: Calibrated parameters

4 Wage and productivity dynamics

This section presents the effects of the employment shift on key economic variables with a special focus on the dynamics of real wages and productivity. Importantly, while the realized employment gains are associated with long-term improvements of most key economic variables (section 4.1), the rise in employment is in the initial phase of the transition to the new equilibrium accompanied by a misallocation-induced slowdown of real wage and labor productivity growth, as well as by welfare losses (section 4.2).

4.1 Long-run effects

This section presents the long-run effects of the employment shift. Table 2 compares the long-run economic outcomes in the pre-shock steady state and in the steady state following the employment increase. The rise in employment is triggered by a labor supply shock in the form of a permanent fall in the disutility of labor θ from 2.0146 to 1.7867.[9] This change induces a permanent increase in employment by 8.5 per cent to 0.33. Employment gains are realized in both sectors and, importantly, the economy settles in a new steady state in which the share of high-productivity employment to total employment is equally high as in the pre-labor supply shock phase. The latter implies that the disproportionate allocation of productive resources to the low-growth sector, as presented in the subsequent section, constitutes only a transitory phenomenon and that the new long-run relative labor allocation is identical to its pre-shock value. This property implies that the increase in employment is not permanently associated with a higher degree of misalloction of labor

[9] The labor supply shock is assumed to constitute a one-time, unanticipated shock ("MIT shock").

to low-productivity sectors.

As highlighted in equation (15), the rate of technology growth depends positively on the labor allocated to the high-productivity sector. As a result, the long-term increase in L^T translates into a higher rate of technology growth in the new long-run equilibrium. More specifically, at the new balanced growth path the rate of technology growth corresponds to 1.59% vis-à-vis 1.47% prior to the employment shift. Since labor productivity, defined as $\frac{Y_t^H + P_t^L Y_t^L}{L_t}$, grows at the rate of technology growth on the balanced growth path, also labor productivity grows correspondingly at an increased rate of 1.59% in the new long-run equilibrium. The long-run equilibrium interest rate R increases as a consequence of the surge in the economy's steady state growth rate ($1 + \bar{g} = \beta \bar{R}$).

As to the wage development, on the new balanced growth path real wages grow at the economy's new, increased equilibrium growth rate. Importantly though, and visible also from equation (14), the level of productivity-adjusted real wage $\frac{W_t}{A_t}$ drops permanently. This fall is caused by the standard channel of falling real wages following employment increases and the corresponding decrease in the marginal product of labor in the presence of diminishing returns in production.[10]

To summarize, the labor supply shift results in permanent increases in aggregate employment. Moreover, given increased employment in the high-productivity sector, resources for technology growth increase, raising the overall rate of technology growth and thus the economy's equilibrium growth rate. As at the new balanced growth path real wages grow at the rate of technology growth, in the long-run the employment shift also exerts a positive impact on real wage growth. TFP-adjusted real wages $\frac{W_t}{A_t}$, however, fall permanently below their pre-employment shift value as a result of increased employment in the presence of diminishing returns in the high-productivity sector.

4.2 Misallocation along the transition path

The long-run gains from the employment increases are not realized immediately in full but only gradually over time as the initial phase following the employment shift is characterized by a misallocation of labor to the low-productivity sector l. Figure 2 illustrates the transitional dynamics to the new steady state following the labor supply shock.

[10] The various underlying mechanisms are discussed in greater detail in the subsequent section.

	Initial steady state	Post-shock
θ	2.02	1.79
L	0.31	0.33
L^H	0.07	0.08
L^L	0.23	0.25
$\frac{L^H}{L}$	0.24	0.24
g	1.47	1.59
g_{LP}	1.47	1.59
r	4.01	4.20
$\frac{W}{A}$	1.59	1.55

Table 2: Initial and post-shock steady state allocation
Growth rates and the real interest rate r are denoted in per cent; values are rounded to three decimals.

As illustrated in the left uppermost panel, the employment increase is triggered by a permanent fall in the disutility of labor θ from 2.0146 to 1.7867 which can be interpreted as a decrease in individuals' outside option of working. This shift causes an increase of the labor supply and employment upon impact and employment further increases over the subsequent periods until it reaches its new steady state value of 0.33 after 10 periods.[11] Concerning the relative labor allocation across sectors, initial employment increases are predominantly realized in the low-productivity sector due to the presence of hiring costs in the high-productivity sector. As firms in the low-productivity sector do not face costs of hiring, sector l employment increases substantially upon impact, while the employment gains in the high-productivity sector are initially small and increase only gradually to their new steady state value over time. As high-productivity sector employment is prevented from equally absorbing the employment increases, the ratio of high-productivity workers in total employment falls substantially relative to the initial steady state ratio.

The employment gains in the high-productivity sector h foster knowledge accumulation as a result of increased resources in the learning-by-doing process (15) and hence raises the rate of technology growth g_t immediately in the initial phase following the transition. The growth rate of labor productivity, however, drops initially. This is the result of two channels. Firstly, in the presence of diminishing returns in sector h production, employment increases are accompanied by a fall in average productivity. Secondly, and most importantly, the positive impact of the increase of overall technology growth g_t on labor productivity is not proportional to the employment increase as a result of the misallocation of workers to the low-productivity sector.

[11] The model is calibrated so that after 10 years the transition to the new long-run equilibrium is concluded. With regards to the German economy, this implies that from the point of view of this model, the transition to the new balanced growth path was completed by 2014.

Over time, however, the drop in the share of high-productivity sector employment in total employment begins to reverse due to gradual hiring in sector h as labor moves from the low- to the high-productivity sector. These employment gains in the high-productivity sector raise resources for knowledge accumulation in the economy, which translate into further increases in the rate of technology growth g_t. Improvements in technology growth also increases the growth rate of labor productivity g_t^{LP}. On its new balanced growth path, the transitory misallocation of productive resources is reversed and the ratio of high-productivity labor in total employment returns to its pre-supply shock level.

The labor supply shift further exerts important effects on the development of real wages. Following the employment expansion, real wages fall as a result of realized employment gains, while high-productivity sector total factor productivity A_t increases due to employment gains in h, resulting in a fall of the ratio $\frac{W_t}{A_t}$. In the subsequent periods, real wages grow at a faster rate than technology growth, reflected in a rise of $\frac{W_t}{A_t}$. Nonetheless, $\frac{W_t}{A_t}$ on the new balanced growth path falls permanently short of its pre-employment shock value as a result of increased steady state employment under diminishing returns in high-productivity production, as also illustrated by equation (14). This permanent decline implies that the initial divergence of real wage and total factor productivity development is not made up for in full along the transition path. Nevertheless, real wage growth in the new long-run equilibrium exceeds its pre-shock counterpart as real wages grow at the new balanced growth path at the increased rate of technology growth.

Lastly, the post-shock steady state real interest rate R_t is higher than before the employment expansion. We can observe that along the transition, the real interest rate temporarily overshoots, which is the result of agents consumption smoothing motive: In the initial phase following the shock, output grows more strongly than at its equilibrium rate on the new balanced growth path as a result of the realized increases in both technology growth and the rise in employment. As agents seek to smooth consumption, the real interest rate rises temporarily above its equilibrium level before it adjusts to its new equilibrium level.

This model provides a qualitative analysis of decelerating real wage and productivity growth following a substantial employment shift and hence does not aim to quantitatively match the observable dynamics in Germany following its labor market reforms. Importantly though, the model-implied dynamics display qualitatively a close fit to the

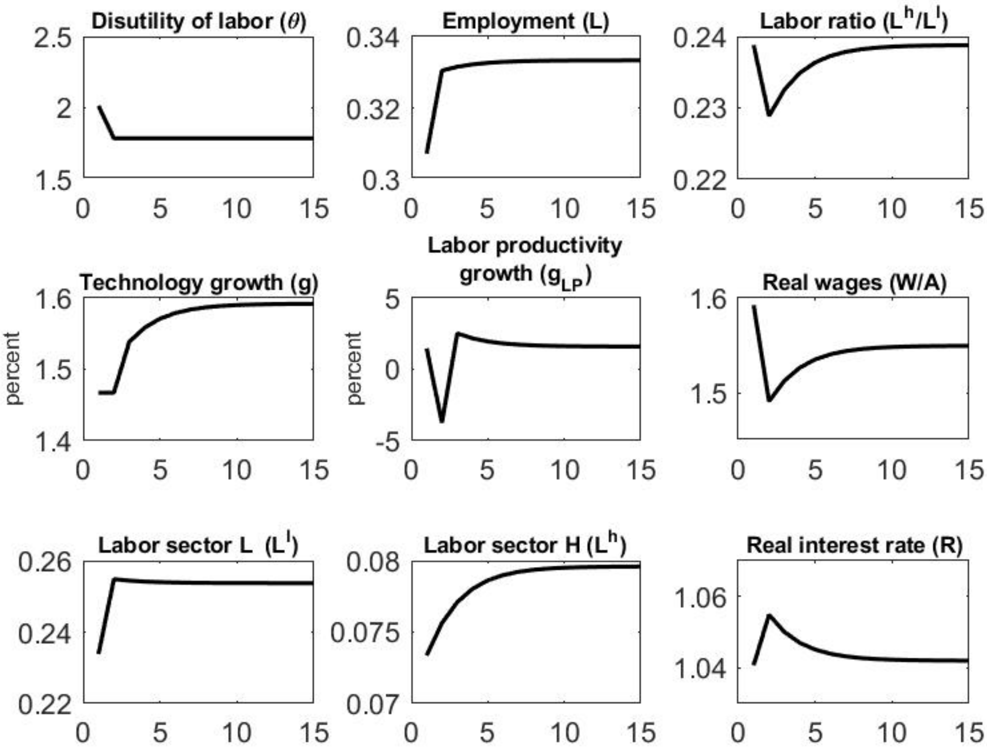

Figure 2: Transitional dynamics following a labor supply shock

post-reform dynamics in Germany. This holds particularly true for the dynamics of key economic variables this model was constructed to feature, as presented in the stylized facts in section 2. More concretely, the model is capable of matching a pronounced employment increase, which is initially predominantly realized in low-productivity sectors, while this feature reverses over time, as we can observe empirically observed. Moreover, the slowdown in labor productivity growth implied in the model is also clearly discernible in the data.[12] Lastly, real wages are both in the model and in the data stagnant for an extended period of time after the reform but start to increase in later stages following the employment shock.

To summarize, the economy realizes considerable employment gains following the labor supply shock. The effect on real wages and productivity depends crucially on the considered horizon, as the transition phase is characterized by a sectoral misallocation of labor to the low-productivity sector with the corresponding negative effects on labor productivity and hence the evolution of real wages. Over the long-run, by contrast, the economy realizes a higher rate of technology growth and thus productivity growth and hence a higher aggregate growth rate on the new balanced growth path. The ratio $\frac{W_t}{A_t}$ falls permanently short of its pre-shock level as a result of the reduced average marginal product of labor given the realized employment increases, putting a wedge between total factor productivity and wages. Nonetheless, higher technology growth also translates into higher real wage growth in the new long-run equilibrium, which implies that the benefits from the labor market shift are also passed on to workers in the form of higher real wage growth.

5 Inefficiency of the competitive equilibrium

The results presented in the previous section indicated that firms do not internalize the effect of their employment choices on the evolution of the stock of knowledge and ultimately on the long-run growth rate in the economy. Given the presence of this growth externality, the competitive allocation is not efficient. I demonstrate the inefficiency of the competitive equilibrium in what follows by deriving the social planner problem, its optimality conditions, as well as the resulting implications for the optimal resource allo-

[12] While both in the model and in the data a sustained slowdown in labor productivity is observable in the follow-up of the reforms, the model foresees a rebound in productivity growth, which is at this point not yet discernible in the data. This is owed to the well-established fact that a host of factors weigh on productivity growth in advanced economies, which add additional downward pressure on the evolution of productivity, ranging from the impact of an ageing society to diminished innovation capacity owed to the third industrial revolution having entered a phase of diminishing returns (see for instance Schmöller (2018) for an overview of potential drivers of the productivity slowdown).

cation relative to the competitive equilibrium. Crucially, I find that relative to the social planner's choice, employment in the high-productivity sector is inefficiently low in the decentralized economy, as the social planner takes into account the effect of the relative labor allocation on the aggregate growth performance of the economy, giving rise to the notion of resource misallocation in the competitive equilibrium.

5.1 Social planner problem

In contrast to the competitive equilibrium, the social planner takes directly into account the effect of its decisions on the evolution of the technology stock, aggregate productivity and the economy's long-run growth potential. Hence, while firms in the competitive equilibrium do not internalize the impact of their labor allocation choice on technology growth, the social planner directly internalizes the growth externality resulting from learning-by-doing in the high-productivity sector. In particular, the social planner's decisions factor in the additional aggregate income which can be generated by raising the production in the high-productivity sector. The social planner chooses the variables $\{C_t^h, C_t^l, L_t^h, L_t^l, L_t, A_{t+1}\}$ to maximize households' expected utility subject to the resource constraints in the economy. More specifically, the social planner's problem can be stated as follows

$$\max_{C_t^h, C_t^l, L_t, L_t^h, L_t^l, A_{t+1}} \sum_{t=0}^{\infty} \beta^t \left(log(C_t) + \theta_t log\left(1 - L_t\right)\right)$$

subject to the resource constraints

$$C_t^h = A_t (L_t^h)^{1-\alpha} - A_t \frac{\psi}{2} \left(\frac{\Delta L_t^h}{L_{t-1}^h}\right)^2 L_{t-1}^h \mathbf{I}\left(\Delta L_t^h\right),$$

$$C_t^l = L_t^l,$$

$$L_t = L_t^l + L_t^h,$$

as well as the process of knowledge accumulation

$$A_{t+1} = A_t \left(1 + \epsilon L_t^H d_t^{\kappa}\right).$$

Let us denote the Lagrange multipliers as λ^{C^h}, λ^{C^l}, λ^L and λ^A in the order of the stated constraints and the optimality conditions can be obtained as

$$\frac{\omega}{C_t^h} = \lambda_t^{C^h}, \tag{21}$$

$$\frac{1-\omega}{C_t^l} = \lambda_t^{C^l}, \tag{22}$$

$$\frac{\theta_t}{1-L_t} = \lambda_t^L, \tag{23}$$

$$A_t \left[\lambda_t^{C^h} \left((1-\alpha) \left(L_t^h\right)^{-\alpha} - \psi \frac{\Delta L_t^h}{L_{t-1}^h} \mathbf{I} \left(\Delta L_t^h\right) \right) \right] + A_t \lambda_t^A \epsilon \left(1-\kappa\right) d_t^\kappa = \lambda_t^L, \tag{24}$$

$$\lambda_t^{C^l} = \lambda_t^L, \tag{25}$$

$$\lambda_t^A = \beta \lambda_{t+1}^{C^h} \left[(L_{t+1}^h)^{1-\alpha} - \frac{\psi}{2} \left(\frac{\Delta L_{t+1}^h}{L_t^h} \right)^2 L_t^h \mathbf{I} \left(\Delta L_{t+1}^h\right) \right] + \beta \lambda_{t+1}^A \left(1 + \epsilon L_{t+1}^h d_{t+1}^\kappa\right). \tag{26}$$

Let us now turn to the impact of an employment shift in the social planner equilibrium. Figure 3 demonstrates the effect of a labor supply shock on the key economic variables in the social planner allocation as opposed to the competitive equilibrium and we can observe the following central differences. Firstly, the social planner allocates substantially more labor to the high-productivity sector throughout the transition to the new balanced growth path. Importantly, the initial drop in employment in the high-productivity sector versus the low-productivity sector is by far less pronounced in the social planner equilibrium. Moreover, the transition time to the new steady state is markedly reduced as the social planner seeks to alleviate the misallocation of productive resources alongside the transition path. Lastly, the social planner also raises the total share of labor allocated to the high versus low-productivity sector at the new balanced growth path as well as total employment in the economy. These observations reflect the social planner's awareness of the impact of its employment choices on the rate of technology growth, aggregate productivity and ultimately the economy's long run growth potential. This is strongly reflected in the evolution of technology growth: By choosing a higher aggregate employment level and hence allocating overall more productive resources to production, as well as by allocating an increased share of total employment to the economy's growth engine, the social planner realizes substantially higher rates of technology growth and thus long-run growth vis-à-vis the competitive equilibrium. This property emphasizes also the fact that the initial disproportional employment gains in the low-growth sector are inefficient and can hence constitute a form of resource misallocation.

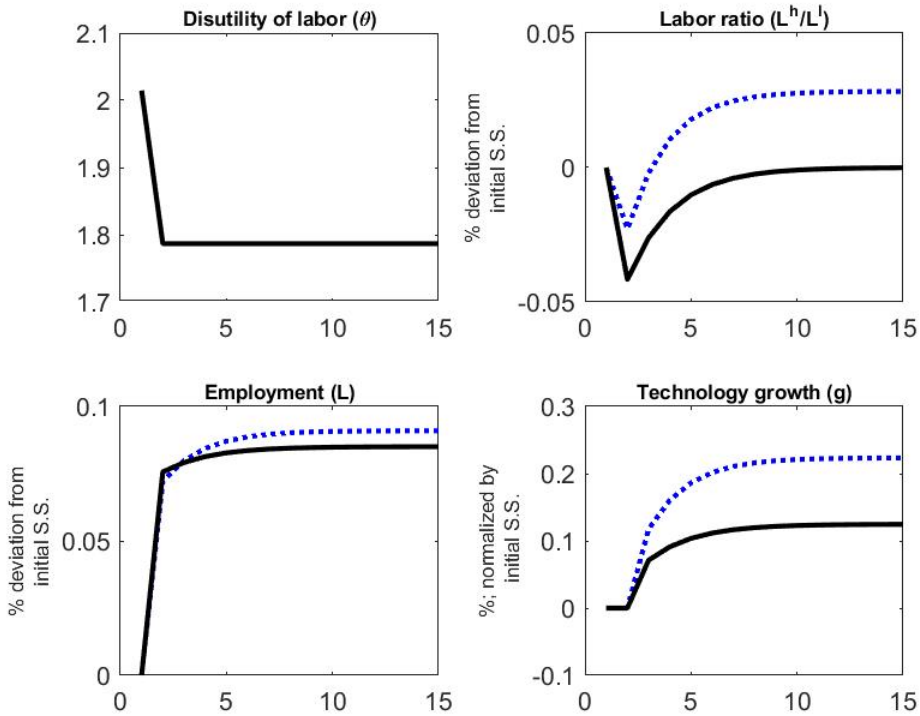

Figure 3: Transitional dynamics
Black solid lines: dynamics in the decentralized economy; blue dotted lines: dynamics in the social planner economy; aggregate employment L_t and the employment ratio $\frac{L_t^h}{L_t^l}$ are denoted in terms of percentage deviations from the initial, i.e. pre-supply shock steady state allocation; the rate of technology growth g_t is normalized by the growth rate at the initial balanced growth path $g_{CE}^{\bar{1}}$ and $g_{SP}^{\bar{1}}$ respectively and the transition graph hence depicts the percentage point increase in the technology growth rate relative to the initial balanced growth path $g_t - \bar{g}^1$.

5.2 The role of the growth externality

This section demonstrates analytically the mechanisms driving the wedge between the allocation in the social planner's problem and the decentralized economy and shows that the presence of a growth externality resulting from the process of knowledge accumulation (15) is key in generating the inefficiency in the competitive equilibrium. To understand the role of the growth externality in this context, combine equations (24) and (25) to obtain a condition determining the relative allocation of labor across sectors in the economy

$$A_t\left[(1-\alpha)\left(L_t^h\right)^{-\alpha}-\psi\frac{\Delta L_t^H}{L_{t-1}^h}\mathbf{I}\left(\Delta L_t^h\right)\right]+\underbrace{A_t\frac{\lambda_t^A}{\lambda_t^{C^h}}\epsilon\left(1-\kappa\right)d_t^{\kappa}}_{growth\ externality}=\frac{\lambda_t^{C^l}}{\lambda_t^{C^h}}. \tag{27}$$

In the absence of a growth externality ($\epsilon = 0$), the labor allocation to the high-growth sector does not exert any effect on technology growth and the social planner equilibrium and the competitive equilibrium coincide. To see that this holds true, consider the case $\epsilon = 0$. Then, just as in the competitive equilibrium, the growth externality would not play a role in the social planner allocation and the previously stated condition would correspond to

$$A_t\left[(1-\alpha)\left(L_t^h\right)^{-\alpha}-\psi\frac{\Delta L_t^H}{L_{t-1}^h}\mathbf{I}\left(\Delta L_t^h\right)\right]=\frac{\lambda_t^{C^l}}{\lambda_t^{C^h}}.$$

To see how this links to the allocation in the competitive equilibrium, recall that in the decentralized economy $W_t = P_t^l$ applies and combined with equation (14) one can obtain $A_t\left[(1-\alpha)\left(L_t^h\right)^{-\alpha}-\psi\frac{\Delta L_t^H}{L_{t-1}^h}\mathbf{I}\left(\Delta L_t^h\right)\right] = P_t^l$. As the relative price P_t^l in the competitive equilibrium can be understood as the ratio of shadow prices $\left(P_t^l = \left(\frac{\lambda_t^{C^l}}{\lambda_t^{C^h}}\right)_{CE}\right)$, it follows straightforwardly that $\left(\frac{\lambda_t^{C^l}}{\lambda_t^{C^h}}\right)_{SP} > \left(\frac{\lambda_t^{C^l}}{\lambda_t^{C^h}}\right)_{CE}$ for $\epsilon > 0$. This holds true as the social planner takes into account in its decision making the effect of the labor allocation to the high-productivity sector on technology growth which arises from the growth externality. As from equations (21) and (22) follows that the relative consumption and hence labor allocation in sector h as opposed to sector l is increasing in the ratio $\left(\frac{\lambda_t^{C^l}}{\lambda_t^{C^h}}\right)$, the social planner allocates a relatively higher share of labor to the high-productivity sector as a result of its effect on the economy's growth performance:[13]

$$\left(\frac{L_t^h}{L_t^l}\right)_{SP} > \left(\frac{L_t^h}{L_t^l}\right)_{CE}.$$

[13]Technically this holds true as $A_t\lambda_t^A\epsilon\left(1-\kappa\right)d_t^{\kappa} > 0$.

While this implies a relatively higher share of employment in the high-productivity sector versus the low-productivity in the steady state, this result has also important implications for the transition to the balanced growth path as the social planner eliminates the distortively low relative labor allocation to the high-productivity sector. This findings also shows that the initial disproportionally low allocation to sector h constitutes a misallocation of productive resources in the economy. Note also that, generally, the effect of the growth externality on resource allocation in the social planner problem is the stronger, the higher the Lagrange multiplier λ_t^A which denotes, as stated in equation (26), the value the social planner attributes to raising productivity in the economy.

In addition to raising the ratio of high-productivity to low-productivity employment $\frac{L_t^h}{L_t^l}$ and given the endogeneity of the labor supply, the social planner raises sector h employment also by increasing total employment L_t:

$$(L_t)_{SP} > (L_t)_{CE} .$$

Appendix (A.1) provides a formal proof for higher overall employment in the social planner equilibrium. Lastly, while the misallocation along the transition path is the main focus of this analysis, note that these findings also imply an inefficiently low labor allocation to the high-productivity sector on the balanced growth path in the decentralized economy, which implies an inefficient degree of technology growth in the steady state. This is in line with a feature frequently prevalent in standard endogenous growth models, namely an inefficiently low overall level of technology-enhancing investment in the competitive equilibrium (Romer, 1990).

6 Policy implications

The previous sections have demonstrated the effects of the employment shift on key economic variables. We now turn to the implications of these findings for macroeconomic policy with a special focus on potential complementary policy options to alleviate the resulting inefficiencies given the misallocation along the transition path. Section 6.1 shows how the social planner allocation can be decentralized in the competitive equilibrium and by that demonstrates the main properties characterizing optimal policy intervention in this context. Section 6.2 presents policy strategies, which are in line with the previously derived options for decentralizing the competitive equilibrium.

6.1 Decentralizing the social planner allocation

This section addresses how the social planner allocation can be decentralized in the competitive equilibrium. A potential policy option to impose the social planner's choice in the competitive equilibrium is subsidizing production in the high-productivity sector h, which is demonstrated in what follows.[14] Firstly, recall that the optimality condition in the social planner equilibrium which internalizes the effect of the labor allocation on the overall rate of technology growth in the economy equals to

$$A_t\left[(1-\alpha)\left(L_t^h\right)^{-\alpha}-\psi\frac{\Delta L_t^h}{L_{t-1}^h}\mathbf{I}\left(\Delta L_t^h\right)\right]+A_t\frac{\lambda_t^A}{\lambda_t^{C^h}}\epsilon\left(1-\kappa\right)d_t^{\kappa}=\frac{\lambda_t^{C^l}}{\lambda_t^{C^h}}.$$

Note further that in the competitive equilibrium with subsidies to production in the high-productivity sector τ_t - financed by lump sum taxes T_t on households, firms maximize profits Π_t^h as described as follows:

$$\max_{L_t^h}\Pi_t^h=\left(1+\tau_t\right)A_t\left(L_t^h\right)^{1-\alpha}-W_tL_t^h-A_t\quad\frac{\psi}{2}\left(\frac{\Delta L_t^H}{L_{t-1}^H}\right)^2L_{t-1}^H\quad\mathbf{I}\left(\Delta L_t^h\right),$$

which delivers the optimality condition in the presence of subsidies:[15]

$$\left(1+\tau_t\right)\left(1-\alpha\right)A_t\left(L_t^h\right)^{-\alpha}-A_t\psi\frac{\Delta L_t^H}{L_{t-1}^h}\mathbf{I}\left(\Delta L_t^h\right)=P_t^l.$$

Since $\frac{\lambda_t^{C^l}}{\lambda_t^{C^h}}=P_t^l$ applies, we can derive the condition for the optimal subsidy by equating the left-hand side of the respective optimality conditions in the social planner allocation (27) and competitive equilibrium under subsidies respectively as:

$$\tau_t=\frac{\frac{\lambda_t^A}{\lambda_t^{C^h}}\epsilon\left(1-\kappa\right)\left(d_t\right)^{\kappa}}{\left(1-\alpha\right)\left(L_t^h\right)^{-\alpha}}.$$

Hence, the optimal subsidy displays the following properties. Firstly, in the absence of the growth externality ($\epsilon=0$), the optimal subsidy is zero as the allocations in the decentralized and social planner equilibrium allocation coincide. Crucially, the stronger the externality in the knowledge accumulation process, i.e. the higher ϵ - the efficiency parameter of sector h labor allocation in generating technology advances - the higher the

[14] The subsequent analysis shows that subsidies to high-productivity production constitute one feasible policy option of decentralizing the social planner allocation in the competitive equilibrium. Potential policy options are, however, not limited to this concrete policy choice. Policies aimed at offsetting the labor adjustment costs in the high-growth sector, for instance, could also achieve the aim of fostering the adjustment to the new high-employment high-growth long-run equilibrium.

[15] The optimality condition in the low-productivity sector $P_t=W_t$ is also imposed in this step.

optimal subsidy to high-productivity production. The underlying reason is that the aggregate resources the social planner can generate by allocating labor to the high-productivity sector are the larger, the stronger the externality as any additional unit of labor allocated to sector h will more strongly impact on the speed of knowledge accumulation and hence both aggregate growth and income. Importantly, the subsidy is also increasing in the distance to the productivity frontier d_t. Consequently, on the transition path to the new balanced growth path, the subsidy will be higher vis-à-vis its steady state level as the social planner intends to increase the speed of convergence to the new high employment-high productivity growth equilibrium. It is worth noting that, nevertheless, the subsidy is non-zero also at the balanced growth path, indicating once more the inefficiently low labor allocation to the economy's growing sector h in the decentralized economy. This effect is the stronger the higher is the relative weight on high-productivity labor L_t^h in knowledge generation versus the distance to the frontier, i.e. the lower κ.

We can now derive the tax corresponding to the optimal subsidy. As stated before, the subsidy is financed via lump sum taxation on households implying that household's decisions are left unaltered in equilibrium. The corresponding lump sum tax on households can be derived as $T_t = \tau_t y_t^h$ and thus as $T_t = \tau_t A_t \left(L_t^h\right)^{1-\alpha}$ which equals to:

$$T_t = \frac{\lambda_t^A}{\lambda_t^{C^h}} \frac{\epsilon (1-\kappa)}{1-\alpha} d_t^{\kappa} A_t L_t^h.$$

Lastly, the household budget constraint in the competitive equilibrium with subsidies to production in the high- productivity sector corresponds to $C_t^h + P_t^l C_t^l + \frac{B_{t+1}}{R_t} = W_t L_t + B_t + \Pi_t - T_t$.

6.2 Options for policy

Based on the theoretical analysis, we can conclude that shocks which raise the labor supply and hence employment will at first be accompanied by a transitional episode in which economic variables adjust towards the new steady state. This transitory phase, however, is characterized by a misallocation of production factors to the low-productivity sector and a deceleration of labor productivity and real wage growth. As demonstrated in the previous section, one feasible policy option to decentralize the social planner equilibrium in the competitive equilibrium is to subsidize production in the high-growth sector. Consequently, sector h production subsidies constitute apt policy tools in alleviating the inefficiencies along the transition path. Hence, in practice, in the case of a positive labor supply shock, policy makers should in the direct aftermaths temporarily subsidize the production in the high-productivity sectors, i.e. in those economic segments, which constitute the growth engines in the economy. By doing so, economic policy can avoid that employment gains are disproportionally realized in low-growth sectors with the concomitant adverse effects on the evolution of technology growth, labor productivity and real wages, emphasizing the active role accruing to policy making in this context.

As a result, labor market reforms aimed at raising employment should be optimally paired with policies promoting job growth not only in low-productivity areas but especially so in those economic sectors, which are essential in promoting productivity growth. More specifically, the ultimate goal post for optimal labor market policies from a welfare perspective constitutes not only, while important in itself, realized employment increases but instead also the quality of employment gains in terms of their contribution to the evolution of aggregate productivity. Put differently, when policy takes the impact on productivity actively into account, it can positively affect the economy's medium-term productivity performance and the rate of the technology growth over this horizon, as well as speed up the transition to the new high employment-high growth steady state and alleviate the corresponding welfare losses.

Moreover, given the role of the hiring costs in governing the length of the initial misallocation period, it should also be a priority for policy making to reduce these costs of labor adjustment to high-productivity sectors and to foster the flow of labor to these sectors. More specifically, supporting retraining and the adjustment of workers to production processes in high-productivity sectors supports the transformation from low into high-productivity employment by reducing firms' corresponding costs of hiring and thus the duration of the employment transition with a positive effect on productivity and real wage growth.

7 Conclusions

Recent economic dynamics in several advanced economies were characterized by a sustained slowdown in productivity as well as stagnant real wage growth, while simultaneously undergoing upward-shifts in employment - triggered for instance by labor market reforms, as implemented among others in Germany from 2003 to 2005. I propose an at this stage unexploited, misallocation-based mechanism, which rationalizes these observations in a single, tractable framework. More specifically, I demonstrate that the phenomena of stagnant real wages and slowing productivity can constitute the result of a temporary misallocation of labor to low-productivity sectors. For this purpose, I derive a nonlinear two-sector endogenous growth model in which productivity is heterogeneous across sectors and technology growth is concentrated in the high-productivity sector, which represents the growth engine in the economy. The model features an endogenous total factor productivity mechanism in the form of learning-by-doing in which technological progress is increasing in the labor allocated to the high-growth sector. Labor is homogeneous and generally mobile across sectors but nonlinear adjustment costs in the high-productivity sector prevent the instantaneous transition of labor to this sector.

In doing so, this paper takes a novel, endogenous growth perspective on the issue of large-scale employment shifts and analyses the impact on technology and thus long-run growth in the economy. I demonstrate by means of this model that the employment expansion is desirable over the long-run as it raises technology and productivity growth, while also fostering the growth of real wages. In the short- to medium-term, by contrast, productivity and real wage growth undergo a phase of stagnation as a result of sectoral misallocation since the employment gains are initially disproportionally allocated to the low-productivity sector. My analysis illustrates that given the growth externality resulting from the learning-by-doing process in the high-productivity sector, the competitive allocation is not efficient as firms in this sector do not internalize the impact of their own labor allocation choice on the evolution of technology growth and hence the performance and welfare of the aggregate economy.

Moreover, the inefficiencies in the competitive equilibrium give a role for policy intervention in this context: I show that subsidies to high-productivity sector production constitute an apt policy tool to alleviate the initial degree of misallocation to the low-productivity sector in the aftermath of the employment shock. By means of these subsidies welfare losses on the transition path to the new high-employment high-growth equilibrium can be alleviated, highlighting the importance of not only the quantity but also the quality of employment in evaluating the recent slowdown in productivity and real wage growth.

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A Appendix

A.1 Social planner equilibrium: Steady state allocation

As outlined in section (5.2), the social planner would allocate more labor to the high-productivity sector by both raising the ratio of high-productivity to low-productivity employment ($\frac{L_t^h}{L_t^l}$) and increasing total employment L_t in the economy. Section 5.2 showed why the relative labor allocation is higher in the social planner equilibrium. This section delivers the underlying mechanism why overall employment in the social planner's choice exceeds its counterpart in the competitive equilibrium. To see that it holds true that the social planner would raise total employment relative to the competitive allocation, use the trade-off between consumption and leisure

$$\frac{\theta_t}{1 - L_t} = \frac{1 - \omega}{C_t^l}$$

which in turn, using the goods market clearing condition for sector l ($C_t^l = L_t^l$), delivers a condition for L_t^l:

$$L_t^l = \frac{1 - \omega}{\theta_t} \left(1 - L_t\right). \tag{28}$$

Based on the latter equality with the labor market clearing condition $L_t = L_t^h + L_t^l$, the following expression for L_t^h can be derived:

$$L_t^h = L_t \left(1 + \frac{1 - \omega}{\theta_t}\right) - \frac{1 - \omega}{\theta_t}. \tag{29}$$

The ratio $\frac{\lambda_t^{C^l}}{\lambda_t^{C^h}}$ can be obtained by combining equation (21) and (22) as $\frac{\lambda_t^{C^l}}{\lambda_t^{C^h}} = \frac{1-\omega}{\omega} \frac{C_t^H}{C_t^L}$. From combining this equality further with the goods market clearing conditions and the respective production functions in both sectors follows

$$\frac{\lambda_t^{C^l}}{\lambda_t^{C^h}} = \frac{1 - \omega}{\omega} \frac{A_t (L_t^h)^{1-\alpha}}{L_t^l}. \tag{30}$$

In combination with the previously derived equation (28) and (29), we receive an expression for $\frac{\lambda_t^{C^l}}{A_t \lambda_t^{C^h}}$:

$$\frac{\lambda_t^{C^l}}{A_t \lambda_t^{C^h}} = \frac{1 - \omega}{\omega} \frac{\left(L_t \left(1 + \frac{1-\omega}{\theta_t}\right) - \frac{1-\omega}{\theta_t}\right)^{1-\alpha}}{\frac{1-\omega}{\theta_t} \left(1 - L_t\right)}. \tag{31}$$

As demonstrated in the previous proof, due to the presence of the growth externality in the economy, $\left(\frac{\lambda_t^{C^l}}{A_t \lambda_t^{C^h}}\right)_{SP} > \left(\frac{\lambda_t^{C^l}}{A_t \lambda_t^{C^h}}\right)_{CE}$ applies, stating that the relative labor allocation $\frac{L_t^h}{L_t^l}$

is higher in the social planner equilibrium since the social planner internalizes the effect, which sector h employment exerts on aggregate growth. Condition (31) demonstrates that this property also coincides with an increase in the overall labor allocation in the economy L_t. To see why this is the case, note that the proof in section (4.2) demonstrated that $\left(\frac{\lambda_t^{C^l}}{A_t \lambda_t^{C^h}}\right)_{SP} > \left(\frac{\lambda_t^{C^l}}{A_t \lambda_t^{C^h}}\right)_{CE}$. As L_t constitutes the only variable on the right hand-side of equation (31), an increase in the left-hand side has to be brought about by an increase in L_t.[16] Hence, as a result, the social planner allocation is also subject to a higher overall employment level than is the case in the competitive equilibrium:

$$(L_t)_{SP} > (L_t)_{CE} . \blacksquare$$

[16]The sign of the change in L_t has to be positive as the right-hand side of equation (31) is increasing in L_t.

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