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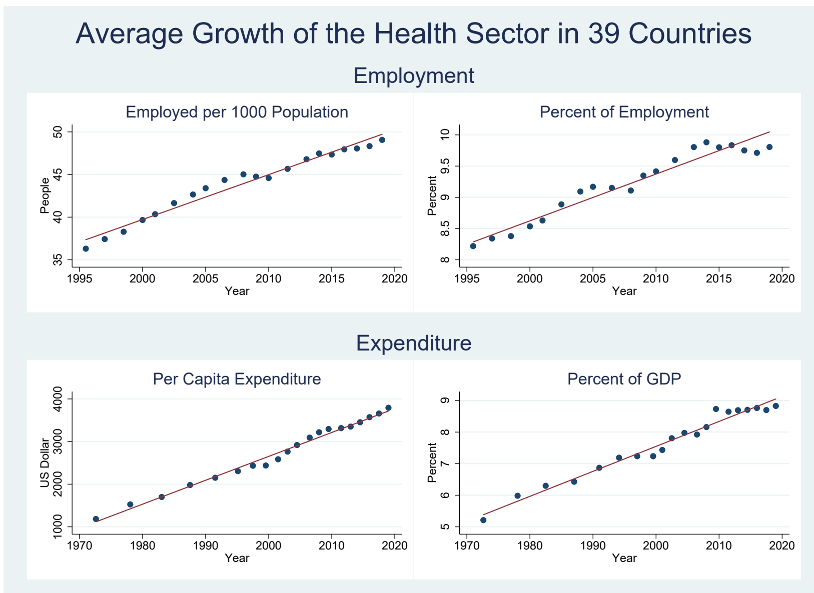
Abstract

Expenditures on healthcare and employment in the healthcare sector have been steadily increasing across OECD countries for many years. This shift of expenditure and employment towards a consistently found to be less productive sector has often been associated with the idea of Baumol's (1967) cost disease. This paper investigates if diagnosing the healthcare sector with suffering from a cost disease is an apt description of the observed reallocation. The novel feature of the paper is to introduce a microeconomic foundation to the theoretical analysis of the healthcare sector. We show analytically in a model that the demand side is very important in determining equilibrium quantities and prices. Even if there is unequal technological progress in the two sectors, the unchanged demand of households dictates that the output level of the two sectors remains constant. This leads to the prima facie unintuitive result of factor allocation towards the less productive sector, in this case, healthcare. We show that this is the case under innocuous assumptions if goods are complements. We supplement the new theoretical results by testing implications from the model empirically. Specifically, we use household-level data to estimate the elasticity of substitution between healthcare consumption and all other consumption. We find robust evidence for the complementarity of healthcare consumption and all other consumption.

1 Introduction

For many decades, healthcare expenditures as a share of GDP have been continuously on the rise in OECD countries. At the same time, employment in the health sector relative to the rest of the economy has also increased, see Figure 1.[1] Moreover, there is wide agreement that productivity growth in the health sector relative to the rest of the economy is lower (see Sheiner and Malinovskaya (2016) and Okunade and Osmani (2018)).



This figure provides a graphical illustration of the trend in employment and expenditure in the healthcare sector. Data from the OECD on 39 countries are combined, which are listed in Appendix B.1.

Figure 1: *Employment and Expenditure in the Healthcare Sector*

One concept that has been used in the past to study these patterns is Baumol's cost disease (Baumol (1967)) - if productivity growth in one sector is higher than in the other and wages in both sectors are positively related, then this entails that the production costs and prices in the less productive sector will grow relative to the more productive sector (see also Nordhaus (2008)). Multiple empirical studies have presented evidence that Baumol's cost disease is indeed partly responsible for the increase in healthcare expenditures as a

[1]In our empirical analysis, we will focus on the case of Germany. All four trends considered in Figure 1 are the same for Germany. The corresponding Figure 4 can be found in the Appendix.

share of GDP (see, for example, Hartwig (2008), Bates and Santerre (2013), Hartwig and Sturm (2014), and Colombier (2017)). Inspired by these findings, a large literature on how best to contain the expenditure disease in the healthcare sector emerged (for a review, see Stadhouders *et al.* (2019)).

However, an open question that remains in this context is whether the rise in health expenditures as a share of GDP and the reallocation of labor to the health sector combined with lower productivity growth in the health sector relative to the rest of the economy is necessarily inefficient or a "disease" and directly warrants government intervention. In this paper, we study this question in more detail and attempt to provide a potential answer to it.

To that end, we build on Acemoglu and Guerrieri (2008) and construct a microfounded two-sector closed economy general equilibrium model, and show under which conditions this model can rationalize the stylized facts presented before. In contrast to Baumol (1967), we explicitly model the demand side and thus the demand for the different goods. We assume preferences are homothetic and therefore rule out any effect operating through the income elasticity of demand.[2] An increase in the level of productivity in the non-health sector leads to an *income* and a *substitution* effect. The reallocation of the flexible production factor, as well as whether healthcare expenditures as a share of GDP increase in response to productivity growth in the non-health sector, depends on which effect dominates. We show that if health and non-health goods are complements the income effect dominates the substitution effect, leading to a reallocation of production factors from the non-health sector to the health sector and an increase in the share of healthcare expenditures as a share of GDP. If they are substitutes, the substitution effect dominates the income effect, and the opposite occurs. In case the elasticity of substitution is one, the two effects exactly offset each other, and the allocation of production factors remains unchanged. Therefore, the central parameter in our framework is the elasticity of substitution between the two goods, which governs whether health and non-health goods are complements or substitutes.

[2] If preferences are non-homothetic and health consumption constitutes a luxury good, an increase in the share of expenditures devoted to health consumption could be explained by higher income levels. However, studies such as Martín *et al.* (2011) and Ke *et al.* (2011) have found income elasticities with respect to health consumption of less than one, i.e., they found evidence that health consumption is not a luxury good.

This entails, that our model, in contrast to the one proposed in Baumol (1967), has additional testable implications that can be examined using available data, i.e., the value of the elasticity of substitution between health and non-health consumption.[3]

Our theory does not depend on any forms of frictions or rigidities to rationalize the empirical findings and thus suggests that the patterns observed in the data are *potentially* optimal from the perspective of a utility-maximizing representative household, i.e., it is optimal to spend a larger fraction of nominal income on the good that is produced in the relatively less productive sector and allocate more production factors to the relatively less productive sector.[4] Therefore, our theory warrants caution when regarding the rise in health expenditures as a share of GDP combined with lower productivity growth in the healthcare sector relative to the rest of the economy as problematic or inefficient.

Whether the pattern in the data is indeed optimal from the perspective of the representative household depends, as mentioned before, on the value of the elasticity of substitution between health and non-health goods. More specifically, we require that the elasticity of substitution between health and non-health goods is below one, i.e., health and non-health goods are complements, in order for our model to rationalize the stylized facts and for the pattern observed in the data to be line with the behavior of a utility-maximizing representative household.

We, therefore, proceed to estimate the elasticity of substitution using German household-level data. Our estimates suggest that the elasticity of substitution is below one, which supports our theory. Moreover, the model makes contrasting predictions regarding the skill premium in the health and non-health sectors, depending on the value of the elasticity of substitution. More specifically, if the elasticity of substitution is below one, an increase in the level of productivity in the non-health sector relative to the health sector leads to a

[3]Baumol (1967) predicts that wages increase in excess of productivity growth in the stagnant sector, and this is how the theory is often tested empirically (see, for example, Hartwig (2008)). Our theory can make the same prediction if we assume that there is a flexible production factor. However, in our model, this ultimately depends on the value of the elasticity of substitution between health and non-health consumption, giving us an additional testable implication.

[4]Our model does not feature any imperfections or externalities, and thus the competitive equilibrium is Pareto efficient by the 1st Welfare Theorem.

higher skill premium in the health sector relative to the non-health sector. This provides us with an additional possibility to assess the validity of our model. Using German wage data, we show that the data supports the prediction our model makes if the elasticity of substitution between health and non-health goods is below one. Subsequently, we extend our analysis to the US, where we find similar patterns.

This paper is related to a large literature on health economics. The existing literature is largely concerned with identifying the determinants of healthcare spending (see for example Erdil and Yetkiner (2009), De Meijer *et al.* (2013), Baltagi *et al.* (2017) and You and Okunade (2017)) or, relatedly, productivity growth in the healthcare sector (see for example Dunn *et al.* (2022), Cutler *et al.* (2022) and Chernew and Newhouse (2011) for a review). In this strand of the literature, of which Getzen and Okunade (2017) provide a concise review, determinants of healthcare spending are analyzed on the macro level. This paper in contrast suggests a microeconomic explanation for increased healthcare spending.

This paper also relates to the large literature on structural change and non-balanced growth (see Herrendorf *et al.* (2014) for an overview). This literature seeks to understand structural change through mechanisms that either pertain to the supply side or the demand side. Theories concentrating on the supply side focus on factors such as differences in rates of technological progress and capital intensities (see, for example, Baumol (1967), Ngai and Pissarides (2007), Acemoglu and Guerrieri (2008), and Duarte and Restuccia (2010)). In contrast, theories focusing on the demand side emphasize the role of non-homothetic preferences, i.e., the income elasticity of demand differs across income groups (see, for example, Kongsamut *et al.* (2001), Boppart (2014), Alonso-Carrera and Raurich (2015), and Comin *et al.* (2021)). In this paper, we contribute to the literature by attempting to combine the two views. To that end, we assume households consume two different goods but otherwise have standard homothetic preferences. If productivity growth in the two sectors differs, this can lead to a reallocation of production factors from one sector to the other. The direction of reallocation is solely determined by the preferences of the households, namely, by the elasticity of substitution. Thus, we highlight the importance of another elasticity, i.e., the elasticity of substitution, relative to the income elasticity of demand, in contributing to explaining structural change.

The rest of the paper is structured as follows. Section 2 introduces the model. In Section 2.4 we derive the theoretical results that serve as testable predictions. Section 3 empirically tests the predictions made by the model and Section 4 concludes.

2 Theory

2.1 Production

We consider a closed economy with no capital. Each good is produced using high- and low-skilled labor with a constant returns to scale production technology. Sector 1 produces good 1 and Sector 2 produces good 2.[5]

The production function for good j with $j \in \{1, 2\}$ is given as

$$Y_{j,t} = L_{j,t}^{\alpha_j} (A_{j,t} H_{j,t})^{1-\alpha_j}, \tag{1}$$

with $\alpha_j \in (0, 1)$.

There are three groups of households: engineers and doctors, who together constitute high-skilled labor and low-skilled workers. Engineers work in Sector 1, i.e., the non-health sector, and doctors work in Sector 2, i.e., the health sector. We assume that high-skilled labor cannot switch sectors.[6] Becoming a high-skilled worker requires acquiring occupation-specific skills through, for example, university studies, which takes time. In our model, we consider the short- and medium-run and therefore assume that workers can't acquire

[5]Throughout the chapter, we use the term good, but this is only done for simplicity and does not imply that we only consider physical products.

[6]While assuming that high-skilled labor cannot switch sectors is certainly an overly restrictive and simplifying assumption, there is evidence for labor mobility to decrease with the education level, which, presumably, is a proxy for skill level. Mincer and Jovanovic (1981) note that the probability to switch jobs is negatively predicted by an individual's education level. In addition, Kambourov and Manovskii (2009) find evidence for occupation-specific human capital. Neffke *et al.* (2017) find that it is mainly workers with low wages in low-skill occupations that change their employment across the industry classification system.

additional occupational skills.[7] Assuming all high-skilled labor is employed implies

$$N_t^e = H_{1,t},$$
$$N_t^d = H_{2,t}.$$

We assume that the low-skilled labor supply is fixed and denoted by N_t^l. Moreover, we assume that, unlike the other production factors, low-skilled labor is fully mobile, i.e., can switch between sectors at no cost.

An equilibrium in the market for low-skilled labor requires

$$N_t^l = L_{1,t} + L_{2,t},$$

where $L_{1,t}$ and $L_{2,t}$, respectively, denote the number of low-skilled workers employed in either sector.

To keep the production side as simple as possible, we assume firms operate under perfect competition and thus take all prices as given and make zero profits in equilibrium. The profit maximization problem of each sector is given as

$$\max_{L_{1,t},H_{1,t}} \pi_{1,t} = p_{1,t} L_{1,t}^{\alpha_1} (A_{1,t} H_{1,t})^{1-\alpha_1} - W_{1,t}^l L_{1,t} - W_{1,t}^h H_{1,t}, \quad (2)$$

$$\max_{L_{2,t},H_{2,t}} \pi_{2,t} = p_{2,t} L_{2,t}^{\alpha_2} (A_{2,t} H_{2,t})^{1-\alpha_2} - W_{2,t}^l L_{2,t} - W_{2,t}^h H_{2,t}. \quad (3)$$

Good 1 is used as the numeraire, and thus $p_{1,t} \equiv 1$.

Define the nominal wage of high-skilled labor, i.e., in terms of the numeraire, of each

[7] Our main results, except for Proposition 3, do not depend on the assumption that high-skilled labor is immobile; see Section A.3 in the Appendix.

group as[8]

$$
\begin{aligned}
w_t^e =& \frac{W_{1,t}^h}{p_{1,t}} = w_{1,t}^h, \\
w_t^d =& \frac{W_{2,t}^h}{p_{1,t}} = w_{2,t}^h,
\end{aligned}
$$

and the nominal wage of low-skilled labor in each sector as

$$
\begin{aligned}
w_{1,t}^l =& \frac{W_{1,t}^l}{p_{1,t}}, \\
w_{2,t}^l =& \frac{W_{2,t}^l}{p_{1,t}}.
\end{aligned}
$$

Using $p_t = \frac{p_{2,t}}{p_{1,t}}$, nominal wages can be written as

$$
\begin{aligned}
w_{1,t}^h =& (1-\alpha_1) L_{1,t}^{\alpha_1} A_{1,t}^{1-\alpha_1} H_{1,t}^{-\alpha_1}, \\
w_{2,t}^h =& p_t (1-\alpha_2) L_{2,t}^{\alpha_2} A_{2,t}^{1-\alpha_2} H_{2,t}^{-\alpha_2}, \\
w_{1,t}^l =& \alpha_1 L_{1,t}^{\alpha_1 - 1} (A_{1,t} H_{1,t})^{1-\alpha_1}, \\
w_{2,t}^l =& p_t \alpha_2 L_{2,t}^{\alpha_2 - 1} (A_{2,t} H_{2,t})^{1-\alpha_2}.
\end{aligned}
$$

Aggregate nominal income of each group is given as[9]

$$
\begin{aligned}
I_t^e N_t^e =& Y_{1,t} - w_{1,t}^l L_{1,t}, \\
I_t^d N_t^d =& p_t Y_{2,t} - w_{2,t}^l L_{2,t}, \\
I_t^l N_t^l =& w_{1,t}^l L_{1,t} + w_{2,t}^l L_{2,t}.
\end{aligned}
$$

[8] To find the real wage rate, we need to calculate a price index, which depends on prices and the structure, as well as parameters, of the utility function; see Section 2.2.

[9] $p_t Y_{2,t} = w_{2,t}^l L_{2,t} + w_{2,t}^h H_{2,t}$ due to perfect competition and constant returns to scale.

Aggregating over the three groups yields aggregate production

$$I_t^e N_t^e + I_t^d N_t^d + I_t^l N_t^l = Y_{1,t} + p_t Y_{2,t}.$$

2.2 Households

Preferences are homothetic, and a household of group i with $i \in \{e, d, l\}$ consumes a final good c_t^i that is produced by combing two goods, i.e., good 1 and good 2, using a CES aggregator. This gives rise to the following maximization problem in nominal terms

$$\begin{aligned} &\max_{c_{1,t}^i, c_{2,t}^i} c_t^i(c_{1,t}^i, c_{2,t}^i) = \left(\gamma^{\frac{1}{\theta}} (c_{1,t}^i)^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} (c_{2,t}^i)^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}} \quad i \in \{e, d, l\} \\ &\text{s.t. } c_{1,t}^i + p_t c_{2,t}^i = I_t^i, \end{aligned} \tag{4}$$

with $\theta \in (0, \infty)$. θ denotes the elasticity of substitution between the two goods. For $\theta \in (0, 1)$, the two goods are complements, and for $\theta \in (1, \infty)$, the two goods are substitutes.

The optimal demand for either good is given as

$$c_{1,t}^i = \gamma \frac{I_t^i}{\gamma + (1-\gamma) p_t^{1-\theta}}, \tag{5}$$

$$c_{2,t}^i = (1-\gamma) p_t^{-\theta} \frac{I_t^i}{\gamma + (1-\gamma) p_t^{1-\theta}}, \tag{6}$$

where $p_t = \frac{p_{2,t}}{p_{1,t}}$ is the relative or nominal price of good $c_{2,t}$.

The price index, i.e., the price of one unit of c_t^i, is given as

$$\mathcal{P}_t = \left(\gamma + (1-\gamma) p_t^{1-\theta}\right)^{\frac{1}{1-\theta}}.$$

We assume that preferences are the same across groups, i.e., all households are symmetric.[10]

[10]See Section A.4 in the Appendix for a short discussion of how heterogeneous preferences could affect the

2.3 Equilibrium

Market clearing requires that, for each good, demand be equal to supply

$$
\begin{aligned}
Y_{1,t} &= \sum_i \gamma \frac{I_t^i}{\gamma + (1-\gamma) p_t^{1-\theta}} N_t^i, \\
Y_{2,t} &= \sum_i (1-\gamma) p_t^{-\theta} \frac{I_t^i}{\gamma + (1-\gamma) p_t^{1-\theta}} N_t^i.
\end{aligned}
$$

We can combine the equilibrium conditions of the two goods markets

$$
\begin{aligned}
\frac{Y_{2,t}}{Y_{1,t}} &= \frac{(1-\gamma) p_t^{-\theta} \sum_i I_t^i N_t^i}{\gamma \sum_i I_t^i N_t^i} \\
p_t^{\theta} \frac{Y_{2,t}}{Y_{1,t}} &= \frac{1-\gamma}{\gamma}.
\end{aligned} \tag{7}
$$

As low-skilled labor is fully mobile, we require an additional equation that determines the equilibrium division of low-skilled labor between the two sectors, i.e., we need to determine the equilibrium values of $L_{1,t}$ and $L_{2,t}$. Full mobility implies that the nominal wage rate in both sectors needs to be equal

$$
w_{1,t}^l = w_{2,t}^l = w_t^l.
$$

In equilibrium, firms maximize their profits, households maximize their utility, all markets clear, and the wage rate of low-skilled labor has to be equal across both sectors. We can characterize the equilibrium as a system of two non-linear equations

model.

$$
\begin{aligned}
F \equiv & p_t^{\theta} \frac{(L_t - L_{1,t})^{\alpha_2} (A_{2,t} H_{2,t})^{1-\alpha_2}}{L_{1,t}^{\alpha_1} (A_{1,t} H_{1,t})^{1-\alpha_1}} - \frac{1-\gamma}{\gamma} = 0 \\
F \equiv & p_t^{\theta} \frac{Y_{2,t}}{Y_{1,t}} - \frac{1}{\gamma} + 1 = 0,
\end{aligned} \tag{8}
$$

$$
\begin{aligned}
G \equiv & w_{1,t}^{l} - w_{2,t}^{l} = 0 \\
G \equiv & \alpha_1 L_{1,t}^{\alpha_1 - 1} (A_{1,t} H_{1,t})^{1-\alpha_1} - p_t \alpha_2 (L_t - L_{1,t})^{\alpha_2 - 1} (A_{2,t} H_{2,t})^{1-\alpha_2} = 0 \\
G \equiv & \alpha_1 \frac{Y_{1,t}}{L_{1,t}} - p_t \alpha_2 \frac{Y_{2,t}}{L_{2,t}} = 0,
\end{aligned} \tag{9}
$$

with p_t and $L_{1,t}$ as the endogenous variables, where p_t is the relative price of good 2 and $L_{1,t}$ the number of low-skilled workers employed in Sector 1. Equation 8 determines the relative price p_t such that the demand and supply for both goods are equalized. Equation 9 is only present if low-skilled labor is mobile.[11] It ensures that the wage in either sector is equal for low-skilled workers.

2.4 Results

Lemma 1. *An increase in $A_{1,t}$ leads ceteris paribus to an increase in the relative price of good 2, i.e., p_t.*

Proof. See Section A.1 in the Appendix. □

A higher level of productivity in Sector 1 relative to Sector 2 entails that good 1 becomes relatively more abundant and good 2 relatively more scarce.[12] Thus, the relative price of good 2 will increase. This is in line with the empirical evidence presented in Nordhaus (2008).

[11] Would we assume that low-skilled labor cannot switch between sectors, the equilibrium could be characterized by only one equation, i.e., Equation 8.

[12] Productivity does not only encompass the level of technology but also other factors that determine how efficiently the input factors can be combined in the production process. A fall in $A_{2,t}$, i.e., the healthcare sector becoming less efficient, would yield the same qualitative results.

Proposition 1. *An increase in $A_{j,t}$ has the following effect on $L_{j,t}$*

$$\frac{\partial L_{j,t}}{\partial A_{j,t}} \begin{cases} < 0 & \text{if } \theta < 1, \\ > 0 & \text{if } \theta > 1, \\ = 0 & \text{if } \theta = 1. \end{cases}$$

Proof. See Section A.1 in the Appendix. □

Proposition 1 states that an increase in the level of productivity in Sector 1, i.e., the non-health sector, can either lead to an inflow or outflow of low-skilled labor from this sector, depending on whether the two consumption goods are complements, i.e., $\theta \in (0,1)$, or substitutes, i.e., $\theta \in (1,\infty)$. Moreover, this also implies that if $\theta \in (0,1)$, a fall in the productivity level of the health sector due to, for example, exogenous distortions or inefficiencies, would lead to a reallocation of low-skilled labor to the health sector.

The economic intuition behind this result is that an increase in $A_{1,t}$ increases $w^l_{1,t}$ directly through a *scale* effect. In addition, it leads to a rise in p_t, which increases $w^l_{2,t}$, i.e., good 1 becomes more abundant, and thus the inverse of its relative price increases, through an indirect *price* effect. In equilibrium, the no-arbitrage condition must be satisfied, i.e., $w^l_{1,t} = w^l_{2,t}$, thus as low-skilled labor is fully flexible, it will switch between sectors if the *scale* effect is larger or smaller than the *price* effect. For $\theta = 1$ the two effects exactly offset each other; for $\theta < 1$, i.e., the two goods being complements, the *price* effect dominates the *scale* effect, which leads to an outflow of low-skilled labor from Sector 1, which increases $w^l_{1,t}$ and reduces $w^l_{2,t}$. For $\theta > 1$, i.e., the goods being substitutes, the *scale* effect dominates the *price* effect, which leads to an outflow of low-skilled labor from Sector 2 and a corresponding inflow into Sector 1, which reduces $w^l_{1,t}$ and increases $w^l_{2,t}$.

We can also interpret our results in terms of an income and a substitution effect. An increase in $A_{1,t}$ makes good 2 more expensive relative to good 1, and thus consumers will consume more of the relatively cheaper good; this is the *substitution* effect. Moreover, a higher level of $A_{1,t}$ also makes the economy altogether richer.[13] This leads to an *income* effect,

[13]As preferences are homothetic and the same for all groups, the distribution of the additional income is not

i.e., households will demand more of both goods. Which effect dominates depends on the elasticity of substitution between the two goods. For $\theta \in (0, 1)$, the income effect dominates the substitution effect, and to satisfy the additional demand for good 2, low-skilled labor is transferred from Sector 1 to Sector 2. If $\theta \in (1, \infty)$, the substitution effect dominates the income effect, leading to a reallocation of low-skilled labor to Sector 1 to meet the additional demand for good 1. For $\theta = 1$, i.e., log utility, the two effects cancel each other out.

Unlike Baumol (1967), we provide a micro-founded theory and explicitly model how the flexible production factor is allocated between the two sectors. A reallocation of production factors from the sector that experiences an increase in productivity relative to the other sector might at first seem counterintuitive, as it reduces overall physical output, i.e., $Y_{1,t} + Y_{2,t}$. However, the utility of households in this economy is *not* necessarily maximized by maximizing the physical production of the two goods; that would only be the case if the two goods are perfect substitutes, i.e., $\theta \to \infty$. Rather, households want to consume an optimal relative bundle of the two goods, which depends on preferences and relative prices as well as the elasticity of substitution.[14]

Moreover, recall that our model does not feature any form of imperfections or externalities, and thus the competitive equilibrium derived here is Pareto efficient by the 1st Welfare Theorem. Therefore, if the economy devotes more income and resources to the less productive sector, i.e., the health sector, this does not necessarily mean that the economy suffers from a form of inefficiency or "disease" that warrants government intervention. Rather, it could be the case that preferences, i.e., the elasticity of substitution, are such that the income effect dominates the substitution effect.

Proposition 2. *If $\alpha_1 = \alpha_2 = \alpha$, an increase in $A_{1,t}$ always has the following effect on the share of*

relevant.

[14]Combing the first order conditions of the representative household yields $\frac{c_{1,t}}{c_{2,t}} = \frac{\gamma}{1-\gamma}\left(\frac{p_{2,t}}{p_{1,t}}\right)^{\theta}$.

good 1 in nominal GDP, i.e., $\xi_t = \frac{Y_{1,t}}{Y_{1,t}+p_t Y_{2,t}}$,

$$\frac{\partial \xi_t}{\partial A_{1,t}} \begin{cases} < 0 & \text{if } \theta < 1, \\ > 0 & \text{if } \theta > 1, \\ = 0 & \text{if } \theta = 1. \end{cases}$$

Proof. See Section A.2 in the Appendix. □

There are three channels through which an increase in $A_{1,t}$ can influence ξ_t in this model. First, directly by increasing the output produced in Sector 1. Second, by triggering a reallocation of low-skilled labor from one sector to another. Third, by influencing the relative price of good 2 and thus affecting the nominal value of output produced in Sector 2. The first and third channels have opposite effects on ξ_t. The sign of the effect of the second channel on ξ_t depends on the value of θ. The result of the above proposition remains unchanged if we assume that, unlike in Baumol (1967), all production factors are immobile.

Let $\phi_{j,t}$ denote the skill premium in sector j. Thus, the skill premium in Sector 1 is given as

$$\phi_{1,t} = \frac{w^h_{1,t}}{w^l_{1,t}} = \frac{1-\alpha_1}{\alpha_1}\frac{L_{1,t}}{H_{1,t}}, \tag{10}$$

and in Sector 2 as

$$\phi_{2,t} = \frac{w^h_{2,t}}{w^l_{2,t}} = \frac{1-\alpha_2}{\alpha_2}\frac{L_{2,t}}{H_{2,t}} = \frac{1-\alpha_2}{\alpha_2}\frac{L_t - L_{1,t}}{H_{2,t}}. \tag{11}$$

Lemma 2. *An increase in* $L_{j,t}$ *leads ceteris paribus to a higher skill premium in sector* j *and a lower skill premium in sector* k *for* $j \neq k$.

Proof. Follows from $\frac{\partial \phi_{1,t}}{\partial L_{1,t}} > 0$ and $\frac{\partial \phi_{2,t}}{\partial L_{1,t}} < 0$. □

The elasticity of substitution between high- and low-skilled labor is one, and the production function has positive but decreasing returns to scale with respect to high- and low-skilled labor, respectively, i.e., $Y_{L_{j,t}} > 0$ and $Y_{L_{j,t}L_{j,t}} < 0$. In addition, the cross derivatives are positive, i.e., $Y_{H_{j,t}L_{j,t}} > 0$. Thus, an inflow of low-skilled labor will decrease the wage rate of low-skilled labor and increase the wage rate of high-skilled labor, as they are complemented by the additional low-skilled workers. Hence, if low-skilled workers switch from the non-health sector to the health sector, this increases the wage rate of high-skilled workers in the health sector and decreases the wage rate of low-skilled workers in the health sector, and vice versa for the wage rate in the non-health sector.

Proposition 3. *An increase in $A_{j,t}$ leads ceteris paribus to a lower skill premium in sector j and a higher skill premium in sector k if $\theta \in (0,1)$ and to a higher skill premium in sector j and a lower skill premium in sector k if $\theta \in (1,\infty)$ for $j \neq k$.*

Proof. Follows from Proposition 1 and Lemma 2. □

Therefore, a rise in the skill premium in the health sector relative to the rest of the economy can be explained by an increase in the level of technology in the non-health sector if $\theta \in (0,1)$. The intuition for this result is that for $\theta \in (0,1)$ an increase in $A_{1,t}$ leads to an outflow of low-skilled labor from the non-health sector and a corresponding inflow of low-skilled labor into the health sector. Thus, the ratio of low-skilled workers to high-skilled workers increases in the health sector. As this ratio governs the skill premium in our model, the change therein leads to a rise in the skill premium in the health sector relative to the rest of the economy.

As discussed in the introduction, productivity growth in the non-health sector seems to be stronger than in the health sector. Moreover, we observe a rise in health expenditures as a share of GDP and an increase in the share of workers employed in the healthcare sector. Similar to Baumol (1967), our model can potentially replicate these empirical findings. The sufficient condition for our model to do so is that the elasticity of substitution between health and non-health consumption, i.e., θ, is below one. However, in contrast to the former, our model also provides us with additional testable implications that can be tested using available data. The first is whether the elasticity of substitution between health and non-health consumption is indeed below one. The second is whether the skill premium in the health sector has increased relative to the rest of the economy.

3 Testable Model Implications

The model described in Section 2 can be falsified by testing its implications empirically along two lines. First, the model predicts that a reallocation of resources towards the less productive sector, as documented in the introduction, depends on the parameter value of θ. Specifically, the resource reallocation is expected to occur if the two consumption goods considered, in this case, healthcare and all other consumption, are complements. This is equivalent to $\theta < 1$, which is a necessary condition for the mechanism proposed in the model to explain the empirical facts highlighted in the introduction. Using data to test if indeed $\theta < 1$, the model can be falsified. And second, the model predicts that given $\theta < 1$ and higher mobility of unskilled than skilled labor, both the share of unskilled labor and the skill premium in the health sector increase. In the model, this is due to a shift of unskilled labor from the non-health to the health sector. To assess the model's validity and assumptions, both aspects are addressed in this section.

3.1 Preference Estimation

In the introduction, we documented a shift of resources toward the health sector. This reallocation took place despite lower productivity growth in the health sector than in the rest of the economy. The model in Section 2 provides a micro foundation for the mechanisms that can rationalize this finding. It predicts that a shift of resources towards the less productive sector occurs only if the goods produced in the less productive sector are complements to the goods produced in the other sector. The crucial parameter and its restriction to see such a reallocation is $\theta < 1$.

The FOCs from the household maximization can be used to derive the optimal consumption ratio of c_1 and c_2.

$$\frac{c_2}{c_1} = \frac{1-\gamma}{\gamma}\left(\frac{p_1}{p_2}\right)^{\theta}$$
$$\ln\left(\frac{c_2}{c_1}\right) = \ln\left(\frac{1-\gamma}{\gamma}\right) + \theta\ln\left(\frac{p_1}{p_2}\right)$$

This log-linearized ratio can be used to motivate an estimation equation. Of course, other factors besides relative prices and the substitution parameter θ may influence the optimal ratio. We assume that these are captured by the error term ε. The estimation equation is given by

$$\ln\left(\frac{c_{2,t}}{c_{1,t}}\right) = \ln\left(\frac{1-\gamma}{\gamma}\right) + \theta\ln\left(\frac{p_{1,t}}{p_{2,t}}\right) + \varepsilon_t, \tag{12}$$

where ε_t is the error term and $\ln\left(\frac{1-\gamma}{\gamma}\right)$ is the constant.

3.1.1 Data

Equation (12) demonstrates how the elasticity of substitution between healthcare spending and all other consumption spending can be estimated. Using microdata, it can be tested if $\theta < 1$, implying that healthcare consumption is complementary to all other consumption. Specifically, to estimate θ in microdata, variation in both prices and quantities at the household level is necessary. These requirements are met by the German EVS data provided by the Statistisches Bundesamt. It is a triennial household-level survey, providing detailed information on household expenditures, as well as socioeconomic information, for roughly 40,000 representative households in each wave. In addition to reporting very granular expenditure data, the EVS also provides the user with transparently combined aggregate measures for different spending categories, one of them being healthcare. For the estimation, the EVS waves of 2003 and 2018 are used.

The Statistisches Bundesamt collects the EVS data with the primary purpose of constructing inflation measures from it. The official price data, also obtainable from the Statistisches Bundesamt, are derived from the EVS data. We, therefore, use and combine two data sets from the same data source. This guarantees a correspondence of available price sub-indices and consumption categories in the EVS. Since price data is indispensable for the estimation proposed, this constitutes a considerable advantage of using EVS data. For the estimation, it is essential to obtain price variation at the household level. The household-level price data is constructed by weighting the official prices of the sub-categories of consumption with the household-specific shares of expenditure devoted to each sub-category of consumption. Importantly, the data only covers expenditures made by the household. For healthcare expenditures, this means that only those expenditures that are not covered by health insurance are recorded in the EVS. This poses a problem for identification, which is discussed in the next section.

3.1.2 Identification

A common problem with measuring household-level healthcare expenditures is that healthcare spending is often at least partially covered by private or public health insurance. Therefore, healthcare spending by households is likely to be underestimated. In Germany, public health insurance is mandatory and it arguably covers most if not even all necessary treatments. If households report private healthcare spending, it is for services above and beyond the quite generous basic coverage. Analytically, mandatory healthcare insurance can be modeled as the opposite of a subsistence constraint. This is in analogy to the class of Stone-Geary utility functions (going back to Geary (1950) and Stone (1954)). In that case, household preferences are given by

$$\max_{c_{1,t}, c_{2,t}} c_t(c_{1,t}, c_{2,t}) = \left(\gamma^{\frac{1}{\theta}} (c_{1,t})^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} (\kappa \cdot c_{2,t} + (1-\kappa)\overline{x}_2)^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}$$

$$\text{s.t. } p_{1,t}c_{1,t} + p_{2,t}c_{2,t} = I_t \text{ and } c_{2,t} \geq 0$$

where $(1-\kappa)\overline{x}_2$ refers to healthcare spending covered by insurance, which is paid for through taxation, and I_t denotes the net-of-tax income. $\kappa \cdot c_2$ refers to healthcare spending on top of items covered by health insurance. Total healthcare consumption by the household is given by $\kappa \cdot c_{2,t} + (1-\kappa)\overline{x}_2$. In the presence of $\overline{x}_2$, the optimal value of c_2 can be zero, requiring an additional non-negativity constraint in the household maximization problem. For estimation, only households reporting positive private expenditures on healthcare are used, such that the non-negativity is met by all observations included in the estimation. c_1 refers to all other consumption. Analogous to the above, an estimation equation for θ can be derived from the FOCs:

$$\kappa \cdot \frac{\kappa \cdot c_2 + (1-\kappa) \cdot \overline{x}_2}{c_1} = \frac{1-\gamma}{\gamma} \left(\frac{p_1}{p_2}\right)^{\theta} \tag{FOCs}$$

$$\ln\left(\frac{\kappa \cdot c_2 + (1-\kappa) \cdot \overline{x}_2}{c_1}\right) = \ln\left(\frac{1-\gamma}{\gamma}\right) - \ln(\kappa) + \theta \ln\left(\frac{p_1}{p_2}\right) \tag{a}$$

$$\ln\left(\frac{c_2}{c_1}\right) = \ln\left(\frac{1-\gamma}{\gamma}\right) - \ln(\kappa) + \theta_b \ln\left(\frac{p_1}{p_2}\right) \tag{b}$$

Ideally, we would like to estimate Equation (a), which theoretically is guaranteed to result in an unbiased estimate of θ. Since we do not observe $\overline{x}_2$, the only equation we can estimate is Equation (b). This results in an unbiased estimate of θ if the healthcare costs covered by public health insurance are as price sensitive as private healthcare spending. Mathematically, the coefficient of interest is defined as follows:

$$\theta = \frac{\kappa \cdot Cov\left(\frac{c_2}{c_1}, \frac{p_1}{p_2}\right) + (1-\kappa) \cdot Cov\left(\frac{\overline{x}_2}{c_1}, \frac{p_1}{p_2}\right)}{Var\left(\frac{p_1}{p_2}\right)}.$$

The coefficient that can be estimated given the available data is θ_b, which is defined as

$$\theta_b = \frac{Cov\left(\frac{c_2}{c_1}, \frac{p_1}{p_2}\right)}{Var\left(\frac{p_1}{p_2}\right)}.$$

The bias of the estimated coefficient, θ_b, relative to the true coefficient of interest, θ, can be derived mathematically. The estimated coefficient is upward biased whenever

$$\frac{Cov\left(\frac{c_2}{c_1}, \frac{p_1}{p_2}\right)}{Var\left(\frac{p_1}{p_2}\right)} > \frac{\kappa \cdot Cov\left(\frac{c_2}{c_1}, \frac{p_1}{p_2}\right) + (1-\kappa) \cdot Cov\left(\frac{\overline{x}_2}{c_1}, \frac{p_1}{p_2}\right)}{Var\left(\frac{p_1}{p_2}\right)}$$

$$\iff$$

$$Cov\left(\frac{c_2}{c_1}, \frac{p_1}{p_2}\right) > Cov\left(\frac{\overline{x}_2}{c_1}, \frac{p_1}{p_2}\right).$$

A higher covariance between private healthcare spending and relative prices than between insurance-covered healthcare spending and relative prices is a sufficient condition for the estimated value of $\hat{\theta}$ to be upward biased. The inequality of covariances is likely to hold for two reasons. One, it holds if people are less price-conscious when seeking insurance-covered treatments than when seeking medical treatments which have to be paid for privately. Given that people don't even learn about the costs they cause when seeking treatment covered by health insurance, it seems safe to assume that that is the case.[15] Two, the coverage of medical treatments by public health insurance is likely to be less price sensitive than people when deciding to get elective procedures for which they have to pay the costs themselves. There are binding regulations determining which medical treatments have to be covered by public health insurance. The procedure to change these regulations is lengthy and generally not initiated by price changes.[16] Therefore, the covariance of public health insurance coverage and treatment costs is likely to be lower than that of elective healthcare expenditures and

[15] The official website of the German public health insurance details, among other things, the contributions to and benefits of the public health insurance in Germany (only available in German, for a short link see `https://t.ly/wJ78z`).

[16] The German government mandates the Federal Joint Committee (Gemeinsamer Bundesausschuss) to determine the benefits and tariffs of the statutory health insurance funds. Details on its mandate and operation can be found on its official website (only available in German, for a short link see `https://t.ly/xvwPw`)

treatment costs. This results in $Cov(c_2, \frac{p_1}{p_2}) > Cov(\overline{x}_2, \frac{p_1}{p_2})$.

The bias increases in the difference in price variability of $\frac{\overline{x}_2}{c_1}$ and $\frac{c_2}{c_1}$, expressed above by the respective covariances. In addition, note that the bias increases in $(1-\kappa)$, assuming that $Cov\left(\overline{x}_2, \frac{p_1}{p_2}\right) > 0$. Effectively, the bias results from an estimation that disregards an unobserved part of healthcare consumption that has a lower price sensitivity than the observed part of healthcare consumption. If the observed share of overall healthcare consumption increases, the estimation bias decreases. The upward bias can be directly derived as

$$\theta_b = \hat{\theta} = \left(\theta - (1-\kappa)\frac{Cov\left(\overline{x}_2, \frac{p_1}{p_2}\right)}{Var\left(\frac{p_1}{p_2}\right)}\right)\frac{1}{\kappa}.$$

For $\lim_{\kappa \to 1} \hat{\theta} = \theta$, whereas $\lim_{\kappa \to 0} \hat{\theta} = \infty$.

When consuming out-of-pocket healthcare, the basic healthcare needs of consumers in Germany have already been met by public health insurance. Estimating the empirical model given by (12) (which is equivalent to Equation (b)), this is not accounted for. Thus $\hat{\theta}$ is biased upward in the presence of relatively price-inelastic, mandatory, and sufficiently generous healthcare insurance. The bias invariably works against finding complementarity of healthcare spending and all other consumer spending.[17]

Eliminating the bias and obtaining unbiased estimates would require data on both the health insurance premium directly subtracted from income, as well as a monetary estimate of the health care sought out but paid for by the insurance on the individual level. Unfortunately, this is not possible due to data availability. Based on Equation (12), we proceed to estimate θ using the German EVS data. Keeping in mind the upward bias mandatory health insurance exudes on the estimated coefficient, this estimation can still provide us with insightful results.

[17]Note that the bias described here is different from a classical measurement error in the dependent variable. This would require the measurement error $\overline{x}_2$ to be independent of c_2. The generosity of the public health insurance coverage however is very likely to be correlated with private healthcare spending, such that the problem at hand cannot adequately be described with classical measurement error.

3.1.3 Estimating θ

For the estimation of Equation (12), the aggregated value for health spending relative to the rest of consumption spending is analyzed. If using aggregated values, the price for health spending is constant across all observations, as variation in the composition of health spending across individuals cannot be used. This implies that only cross-year analysis is feasible. Results from the structural equation estimation are reported in Table 1.

The main regression result is reported in column one, using the whole pooled EVS sample. In addition, columns two, three, and four report the estimated elasticity of substitution for subsamples divided along the income distribution. In theory, we would expect both preference parameters γ (estimated indirectly by the constant) and θ to be constant across all subsamples. The theory is derived with the clearly simplifying assumption of a representative agent, such that obtaining non-varying estimates of the two preference parameters in survey data is unrealistic. If, however, the estimated values of the parameters are reasonably stable across subsamples, it suggests some robustness of the results. In particular, it is of special interest to see if θ is estimated to be above or below the value of one.

Table 1: *Estimating θ by Income Group*

	All	Bottom 50%	Next 40%	Top 10%
$\hat{\theta}$	0.017	0.149	0.161	1.331
	[-0.19,0.22]	[-0.12,0.42]	[-0.17,0.49]	[0.58,2.08]
Constant	-3.973	-4.087	-3.949	-3.661
	[-3.99,-3.96]	[-4.11,-4.07]	[-3.97,-3.93]	[-3.71,-3.61]
Observations	77,501	37,089	32,219	8,193

Note: Dependent variable is the log ratio of health to all other expenditures as reported in the 2003 and 2018 waves of the EVS. Significance stars are suppressed because they are not informative in this context. The numbers in brackets report the 95%-confidence interval. The constant represents the estimate of $\ln\left(\frac{1-\gamma}{\gamma}\right)$.

From the reported confidence intervals it is quite clear that $\hat{\theta}$ is estimated to be smaller than one, except in the subset of the Top 10% of highest income households. As detailed in the previous section, the estimated coefficients reported in Table 1 are biased upward because of the broad coverage public health insurance provides in Germany.

The finding of increasing estimated values of $\hat{\theta}$ along the income distribution can be rationalized with $\overline{x}_2$, the basic coverage of healthcare costs provided by health insurance, being less relevant as income increases. For low levels of income, the amount of healthcare covered by insurance, $(1-\kappa)\overline{x}_2$, may be larger than optimal from the household's point of view, resulting in the non-negativity constraint of c_2 to be binding, such that $c_2^* \leq 0$. However, as income increases, households may want to consume more healthcare than covered by health insurance, such that the non-negativity constraint of c_2 is no longer binding. Assuming a fixed $\overline{x}_2$ across all households, the share of healthcare costs covered by insurance decreases as income increases. This leads to an increase in the upward bias of the estimated coefficient $\hat{\theta}$, as argued above.

The mathematical explanation can be supplemented by intuitive reasoning, why the upward bias is higher, the higher the household income is. The majority of healthcare expenditures by low-income households, if not zero, is likely to be primarily due to co-payments on drugs, dentures, and other basic medical needs, which households have to make irrespective of their price. Households with higher incomes in contrast may decide to get elective medical treatments such as teeth beautification, skin care, or plastic surgery. This intuition is supported by the expenditure elasticities of healthcare ($\epsilon_{health} = 1.17$) and all other consumption ($\epsilon_{other} = 0.97$).[18] The fact that the expenditure elasticity of healthcare is larger than one whereas the expenditure elasticity of all other consumption is smaller than one signifies that healthcare is a luxury good. As a standard CES-utility function in principle cannot accommodate expenditure elasticities that are different from one, two remarks are in order: One, the expenditure elasticities are once more estimated without taking the fixed amount of healthcare provided by insurance into account. This results in an upward bias in the estimated expenditure elasticity of health consumption. Therefore, the difference between expenditure elasticities of total health consumption and all other

[18] The expenditure elasticities are estimated by regressing the log of healthcare expenditures on the log of aggregate expenditures. Both 95%-confidence intervals of the estimated expenditure elasticities exclude the value one with $ci_{health} = [1.15, 1.18]$ and $ci_{other} = [0.968, 0.971]$.

consumption is likely to be smaller in reality. It highlights again the problems for empirical analysis caused by an only partial observation of healthcare consumption. Two, the finding of non-unit expenditure elasticities implies once more, that in reality preferences cannot be perfectly described by the representative agent with a CES-utility function. Nevertheless, the model described in Section 2 yields valuable insights in highlighting the role played by the demand side in general and the elasticity of substitution in particular when analyzing factor reallocation across sectors.

As these estimates are based on individual consumption expenditures, noise in the data may attenuate the estimated coefficients. However, for the estimation, the consumption aggregates of the EVS were used and merged with official price data on the same consumption aggregates published by the Statistisches Bundesamt. This leaves no room for own interpretation or discretion about the handling of the data. Therefore, any measurement error exerting attenuation bias would lie with the Statistisches Bundesamt. While classical measurement error cannot be ruled out completely, it is likely to be much smaller than the structural upward bias discussed in the previous section. If anything, we expect the estimates to be upward biased.

3.1.4 Alternative θ Estimation

The estimation equation is derived from the FOCs and therefore under the implicit assumption of constant income. Furthermore, there is no theoretical reason for including income as a control variable when estimating θ, as preferences are assumed to be homothetic. The variation of results across columns reported in Table 1 however indicates that the relationship between the consumption ratio and the price ratio changes with income. To investigate and control the role of income in the estimation results, we repeat the estimation, this time including income as an explanatory variable. If preferences are indeed homothetic, we would expect the corresponding coefficient $\hat{\beta}$ to equal to zero.

$$\ln\left(\frac{c_{2,t}}{c_{1,t}}\right) = \ln\left(\frac{1-\gamma}{\gamma}\right) + \theta \ln\left(\frac{p_{1,t}}{p_{2,t}}\right) + \beta \ln(income) + \varepsilon_t \tag{13}$$

Table 2: *Estimating θ with Income Effect*

	All	Bottom 50%	Next 40%	Top 10%
Theta	0.221	0.138	0.287	1.437
	[0.02,0.42]	[-0.13,0.41]	[-0.04,0.62]	[0.68,2.19]
Beta	0.222	0.087	0.407	0.273
	[0.21,0.24]	[0.05,0.12]	[0.33,0.49]	[0.14,0.41]
Constant	-6.018	-4.841	-7.829	-6.442
	[-6.17,-5.87]	[-5.12,-4.56]	[-8.61,-7.05]	[-7.83,-5.05]
Observations	77,473	37,061	32,219	8,193

Note: Dependent variable is the log ratio of health to all other expenditures as reported in the 2003 and 2018 waves of the EVS. Significance stars are suppressed because they are not informative in this context. The numbers in brackets report the 95%-confidence interval. The constant represents the estimate of $\ln\left(\frac{1-\gamma}{\gamma}\right)$.

The results of estimating Equation (13), reported in Table 2, confirm that income plays a role in the relationship between the consumption ratio and the price ratio. The estimates for θ go up if income is included as a control variable. However, they remain smaller than one except in the subsample of the Top 10% of the income distribution, where it is estimated to be larger than one, as in the baseline regression. Income however is positively correlated with the share of consumption made up by healthcare. This once again indicates that healthcare is a luxury good. In our model, we can rationalize a reallocation of resources towards the healthcare sector if $\theta < 1$ under homothetic preferences. The finding reported in Table 2 shows that some of the reallocations towards the healthcare sector may be driven by healthcare being a luxury good. Assuming non-homothetic preferences would thus facilitate modeling a reallocation. Our model however can explain the empirical facts with a minimum of free parameters. While non-homothetic preferences may be part of the story, our model can explain the empirical facts using homothetic preferences, which continue to be the benchmark case in economic models.

The structural estimation in (12) can also be separated out and reformulated, imposing equality and opposite signs for the two price coefficients. The new estimation equation is given by

$$\ln(c_{2,t}) = \ln\left(\frac{1-\gamma}{\gamma}\right) + \theta\ln(p_{1,t}) - \theta\ln(p_{2,t}) + \eta\ln(c_{1,t}) + \varepsilon_t. \tag{14}$$

This does not address the problem of a structural bias in the θ estimate but allows for a more flexible and intuitive estimation. The relationship can be estimated by putting a constraint on the coefficients of $\ln(p_{2,t})$ and $\ln(p_{1,t})$ to be of the same magnitude but have different signs. Results are reported in Table 3.

Table 3: *Alternative Estimation of θ by Income Group*

	All	Bottom 50%	Next 40%	Top 10%
Other Price	0.092	0.633	0.739	1.782
	[-0.11,0.30]	[0.36,0.90]	[0.41,1.07]	[1.04,2.53]
Health Price	-0.092	-0.633	-0.739	-1.782
	[-0.30,0.11]	[-0.90,-0.36]	[-1.07,-0.41]	[-2.53,-1.04]
Other Consumption	0.895	0.701	0.387	0.294
	[0.88,0.91]	[0.67,0.73]	[0.34,0.43]	[0.21,0.38]
Constant	-3.035	-1.548	1.648	3.052
	[-3.20,-2.87]	[-1.80,-1.29]	[1.25,2.05]	[2.21,3.89]
Observations	77,501	37,089	32,219	8,193

Note: Dependent variable is log healthcare expenditures as reported in the 2003 and 2018 waves of the EVS. The two price coefficients are constrained to be equal but of opposite signs. Significance stars are suppressed because they are not informative in this context. The numbers in brackets report the 95%-confidence interval. The constant represents the estimate of $\ln\left(\frac{1-\gamma}{\gamma}\right)$.

In this setup, $\hat{\theta}$ is the estimated coefficient of Other Price, reported in the first row of Table 3. As expected from the previous regressions, it is estimated to be smaller than 1, again indicating that health consumption and other consumption are complements. This is true for the pooled sample as well as the Bottom 50% of the income distribution. As already seen in Table 1, the estimated $\hat{\theta}$ increases over the income distribution, which is what would be expected, given the structure of the upward bias discussed earlier. While the estimated $\hat{\theta}$ remains larger than one for the Top 10% of the income distribution, it is still estimated to be smaller than one for the Bottom 90% and the pooled sample, which is reassuring.

3.2 Factor Reallocation

Under two assumptions, the model predicts a reallocation of unskilled labor to the less productive sector. Assumption one is that the two goods produced are complements, which is the case if $\theta < 1$, supportive evidence of which is presented in the previous section. Assumption two is that unskilled labor is more mobile than skilled labor. This assumption is based on findings in the literature investigating labor mobility. That labor mobility is negatively predicted by education is an empirical finding already shown for the US by Mincer and Jovanovic (1981). This finding is confirmed by Kambourov and Manovskii (2009), who use US data from 1968-1993 to argue that human capital is occupation specific. Using German social security records from 1999-2008, Neffke *et al.* (2017) report that workers in high-income segments switch industries less often than those in low-income segments. Furthermore, if high-income workers do switch industries, they tend to switch to industries that are closely related to their origin industry. In summary, there is ample evidence based on data from the US and Germany, that higher education results in less labor mobility in the sense of sectoral switches.

3.2.1 The Case of Germany

In this section, we test if there indeed was a reallocation of unskilled labor to the healthcare sector, focusing on the case of Germany. Data for this analysis is taken from the German Statistical Office.[19] Optimally, we would like to investigate data spanning the period 2003-2018, such that it is the same as the period over which the preference parameter θ is estimated. However, data is only available as far back as 2007, reducing statistical power.

In the statistic, it is distinguished between five skill levels. For the purpose of this analysis, the two top skill levels are aggregated into a high-skilled group, with the remaining three skill levels aggregated into a low-skilled group. The high-skilled group comprises workers in management positions and specialized positions who have graduated from college and/or have many years of experience and expert knowledge. This definition of high-skilled labor

[19] `https://www.statistischebibliothek.de/mir/receive/DESerie_mods_00000301`

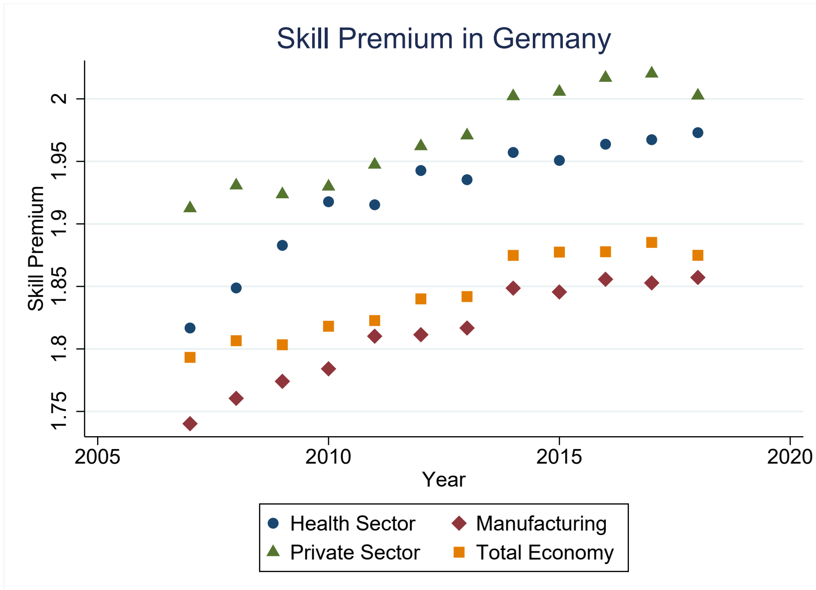
is in line with occupation-specific human capital accumulation found to make employment switches across sectors less likely.

There is barely a change in the share of skilled and unskilled labor in Germany from 2007 to 2018, displayed in Figure 5. The share of high-skilled labor in the healthcare sector decreased from 40.1% in 2007 to 37.0% in 2018. This is the first indicative evidence of an increase in low-skilled labor in the healthcare sector, as predicted by the model. In the overall economy, the share of high-skilled labor increased slightly from 35.8% in 2007 to 36.0% in 2018. Given these small changes, direct analysis of employment shares by skill level is unlikely to yield meaningful results. Instead of measuring the reallocation of different kinds of labor into or out of the healthcare sector, we measure labor mobility indirectly via a skill premium. If the skill premium in one sector increases, it indicates that unskilled labor increases by more than skilled labor, relative to the respective demand for the different kinds of labor in that sector. One advantage of using this measure is that aggregate data is sufficient to investigate the relative mobility of labor rather than requiring individual-level data. A second advantage is that it measures supply relative to the demand for the two kinds of labor, which makes the measure robust to potential structural changes and trends, such as an overall increased supply of skilled labor. The model predicts that the skill premium increased by more in the healthcare sector than in the rest of the economy, which is captured by the parameter ϕ in Section 2.4.

Figure 2 displays the skill premium paid to high-skilled employees in Germany in different sectors. There is a general increase in the skill premium from 2007 to 2018 in Germany, illustrated by the squares in Figure 2. While all sectors considered experience an increase in the skill premium, the increase is fastest in the healthcare sector, illustrated by the dots in Figure 2. These results are indicative of a reallocation of unskilled labor to the healthcare sector, as predicted by the model.[20]

By separately regressing the skill premium for total employment and employment in

[20] All the results presented in this section are calculated based on employment numbers for Germany. There are some particularities with employment in the healthcare sector in Germany, none of which pose a threat to our identification strategy. For details, see Appendix B.2.



This figure provides a graphical illustration of the skill premia paid in the healthcare sector, the manufacturing sector, the private sector, and the overall economy, respectively. Data is taken from the German Statistical Office for the years 2007-2018.

Figure 2: *Skill Premium in Germany in Different Sectors and the Overall Economy*

Table 4: *Estimating the Time Trends of Skill Premia*

	Total	Private	Manu	Health
Year	0.00903***	0.0105***	0.0109***	0.0127***
	(10.96)	(10.24)	(12.23)	(7.61)
Constant	-16.32***	-19.15***	-20.12***	-23.66***
	(-9.84)	(-9.28)	(-11.22)	(-7.03)
R^2	0.92	0.91	0.94	0.85
Observations	12	12	12	12

Note: Dependent variable is the skill premium in the overall economy, the private sector, the manufacturing sector, and the health sector, respectively. Results are obtained using German employment Data from 2007-2018. Significance stars are defined as follows: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. t-statistics in parentheses.

different sectors on a time variable, it can be tested if there is a statistical difference between the skill premium increase in the different sectors. The regression results are reported in Table 4. As foreshadowed by the graphical illustration, the time trend for the skill premium is the steepest in the healthcare sector. A Wald-test of similarity indicates that the null hypothesis of similar trends can be rejected at a $p - value = 0.06$ for total employment. The difference between the time trend in the healthcare sector and the private sector, and the healthcare sector and the manufacturing sector is not statistically significant, with respective p-values of $p - value_{Private} = 0.30$ and $p - value_{Manu} = 0.37$.

The lack of statistical significance between the healthcare sector and the other two sectors may be owing to the short period with available data. It may also be due to the highly regulated labor market in Germany. While providing protection for workers, it reduces the flexibility with which any sector can react to changes in labor demand. The reallocation of unskilled labor, which in principle could easily switch into the healthcare sector to help meet increased demand for healthcare, is thus inhibited by the strong German labor protection laws. This is likely to reduce the expected skill premium increase in the healthcare sector in Germany and works against finding a statistically significant difference between the healthcare sector and other sectors. Both aspects work against finding a statistically significant difference in the time trends of skill premia. That we find (partially) statistically significant results despite these caveats emphasizes the relevance of the model's implications.

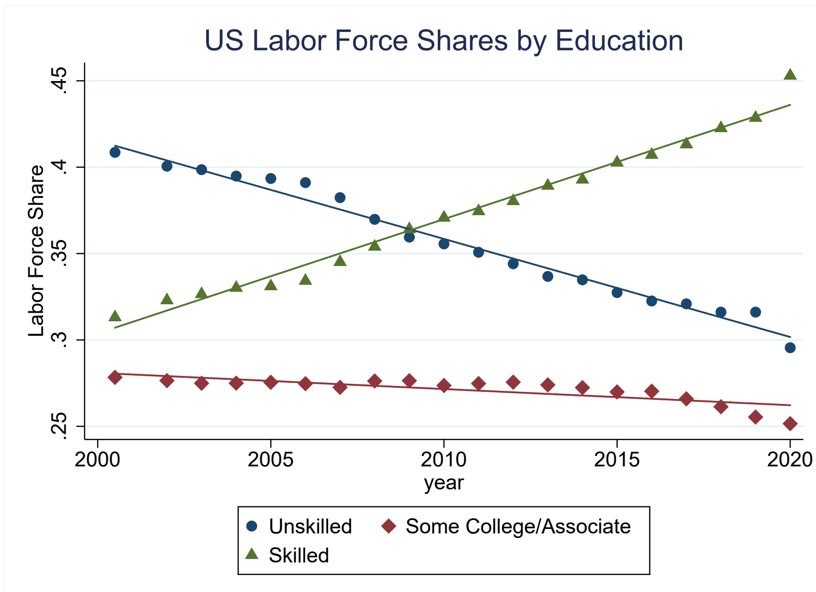
3.2.2 Extending the Analysis to the USA

In this section, we investigate if there was a reallocation of unskilled labor towards the health sector in the US. The purpose of this section is twofold. One, by replicating findings regarding the skill premium found for Germany using US data, the relevance and plausibility of the model is once more demonstrated. Both the healthcare system and the labor market regulation in the US are very different from the ones in Germany. Showing the specific pattern in the skill premium to hold in two distinct countries makes external validity and general applicability of the model likely. Two, the US data covers a longer period and there is a larger variation in skill shares of employment over time, rendering analyses of changes in the share of unskilled labor meaningful. First, we check if a reallocation of unskilled labor towards the health sector took place. The testable implication is that the share of unskilled labor rose faster in the health sector than in the rest of the economy. Second and as discussed before, we analyze if the skill premium increased by more in the health sector than in the rest of the economy, resulting from a reallocation of unskilled labor towards the health sector.

Each year, the US Bureau of Labor Statistics releases wage data for different education levels in the whole US economy. According to the data, the share of unskilled labor (measured as the share of workers with a high school degree or less) decreased from 39.9% to 31.6% from 2003 to 2018, a decrease of 21%. At the same time, the share of skilled labor increased from 32.7% to 42.3%. Workers with some college experience or an associate's degree are not included in either group, as it is unclear which category they belong to. The share of that in-between education group is rather large, on average making up 27% of the labor force. However, this share stays quite constant over time, changing from 27% to 26% between 2003 and 2018. The change over time for each skill group is depicted in Figure 3. Contrary to the case of Germany, there is a considerable trend in the shares of differently skilled labor in the total labor force. Overall, unskilled labor decreased, accompanied by a simultaneous increase in skilled labor across all sectors of the US economy.

The statistics cited in the previous paragraph clearly show an increasing time trend in the share of skilled labor across all sectors. To analyze how the share of skilled labor and the skill premium paid changed over the same time within the health sector, a different data set from the US Bureau of Labor Statistics has to be employed, which reports employment and wage statistics for different occupational groups.[21] To distinguish between skilled and unskilled labor, the occupational group "Healthcare practitioners and technical occupations" is compared to the "Healthcare support occupations". The employment share of the unskilled group decreased from 34.2% to 32.3% in the health sector. Thus the share of unskilled

[21] The data is taken from `https://www.bls.gov/oes/current/oes_nat.htm`.



This figure provides a graphical illustration of the trend in employment shares of three different skill groups. It is based on data from the US Bureau of Labor Statistics. Workers with a high school education or less and no professional training are classified to be unskilled and workers with at least a Bachelor's degree are classified to be skilled.

Figure 3: *Skilled and Unskilled Workers*

Table 5: *US Labor Force Changes 2003-2018*

	Overall Economy		Health Sector	
	2003	2018	2003	2018
Unskilled Labor Force	39.9%	31.6%	34.2%	32.3%
Δ		-21%		-6%
Skill Premium	1.87	1.91	2.11	2.23
Δ		+2.1%		+5.7%

Note: Calculations based on data from the US Bureau of Labor Statistics.

employment decreased from 2003 to 2018 by 6% in the health sector, which is much lower than the 21% recorded for the overall economy. The shares of unskilled labor in the overall economy and the health sector are displayed in the first row of Table 5. The respective growth rates are reported in the second row. The fact that the share of unskilled labor decreased by less in the health sector than in the rest of the economy is in line with the prediction made by the model given $\theta < 1$.

Next, it is informative to compare the change in the skill premium between the overall economy and the health sector. As noted before, the share of skilled labor increased in the overall economy in the period 2003-2018. At the same time, the skill premium of college graduates relative to workers with a high school diploma or less increased from 1.87 to 1.91 or by 2.1% across all sectors.[22] When adding those workers with some college or an associate's degree to the unskilled labor forces, thus comparing college graduates to all other workers, the considered changes are of similar magnitude.[23] In the health sector, the skill premium increased from 2.11 to 2.23 or by 5.7% in the same period.[24] So while the skill premium increased in both the overall economy and the health sector, the increase was stronger in the health sector. The skill premium as well as its growth rate in the overall economy and the health sector are displayed in the third and fourth row of Table 5, respectively. The fact that the skill premium increased by more in the health sector than in the overall economy is in line with the model prediction for $\theta < 1$.

[22]The skill premium is measured at the median of the respective education group's wage distribution.

[23]The skill premium of college graduates relative to all other workers changed from 1.70 to 1.76 or by 3.5%. The share of unskilled labor, including all but college graduates, changed from 67.3% to 57.7% or by 14%.

[24]Again, the skill premium is measured for median wages.

Table 6: *Ratios of Key Indicators*

	2003	2018
Unskilled Labor Force Ratio	0.857	1.022
Skill Premium Ratio	1.128	1.168

Note: Calculations based on Table 5, which summarizes data from the US Bureau of Labor Statistics. The ratios implicitly account for time trends and compositional changes in the labor force.

Instead of looking at the share of unskilled labor and the skill premium in each sector separately, the ratio of these indicators can be constructed for each year. While this may be a less intuitive measure, it has the advantage of being unaffected by overall time trends. Specifically, the ratio is constructed as $Ratio_{measure,t} = \frac{\text{measure}_{health,t}}{\text{measure}_{overall,t}}$, with measure referring either to the share of the unskilled labor force or the skill premium. Table 6 displays the ratio of unskilled labor and the skill premium in the health sector relative to the overall economy for 2003 and 2018. For example, the skill premium in the health sector was 1.128 times larger than the skill premium in the overall economy in 2003. In 2018, it was 1.168 times larger in the health sector than in the overall economy. This indicates that the skill premium increased faster in the health sector than in the overall economy. The same is true for the ratio of unskilled labor force shares. By comparing the ratios across time, time trends and overall compositional changes in the labor force are implicitly accounted for.

Overall, there is supportive evidence for the testable model implication of a factor reallocation and ensuing changes in factor remuneration, summarized in Tables 5 and 6. Taking the time trends for both the unskilled labor share and skill premium into account, the development in the health sector of both measures is in line with the model predictions if $\theta < 1$.

One drawback of the US data used here is that the health sector of course is included in the data on the overall economy. The limited data availability prohibits the direct comparison between the overall economy excluding the health sector and the health sector. It implies that the actual difference between the two groups is larger than identified in the imperfect data, which works against finding any differences between the two groups compared here.

To facilitate the comparison of the results concerning factor reallocation in German and US data, Table 5 and Table 6 are replicated using the German data from Section 3.2.1. The tables can be found in Appendix Section B.3 as Table 7 and Table 8. Compared to the case of Germany, the increase in the share of unskilled labor in the health sector relative to the overall economy is more pronounced in the US data. In contrast, the increase in the skill premium paid in the health sector relative to the overall economy is a bit smaller in the US than in the German data. The overall pattern of a more-than-average increase in both the unskilled labor share and the skill premium in the health sector is present in both German and US data. This is remarkable, given the very different labor markets, especially with regard to labor protection laws, and healthcare systems in the two countries.

4 Conclusion

Spending on healthcare as a share of GDP has steadily increased for at least 50 years across 39 countries with available data. Employment in the health sector has mirrored the increase in spending, documenting a reallocation of labor towards the health sector. These two phenomena have been extensively studied by economists, and different explanations for the "excess growth" have been proposed and analyzed (see Getzen (2016) for a review of the literature). In the quest for explanations, the focus has been on macroeconomic variables like income per capita.

The health sector and its increasing share in GDP are often associated with Baumol's cost disease, a phrase based on Baumol (1967). We construct a micro-founded theory that can rationalize the empirical findings and provides us with additional testable implications that can be evaluated using available data.

We show that if the level of productivity increases in one sector relative to the other, this gives rise to a substitution effect and an income effect. The substitution effect entails that more resources flow into the more productive sector, whereas the income effect encompasses the opposite. Which of the two effects dominates depends on the elasticity of substitution between health and non-health consumption. If the elasticity of substitution between health and non-health goods is less than one, i.e., $\theta \in (0, 1)$, for which we provide empirical evidence, higher productivity growth in one sector relative to the other leads to an outflow of the flexible production factor from the more productive sector. Moreover, this can potentially increase the share of the less productive sector in terms of nominal GDP. Therefore, unequal productivity growth increases the relative price of the good produced in the relatively less productive sector and leads to a reallocation of production factors from the relatively more productive sector to the relatively less productive sector. This is in line with Baumol's cost disease. However, in this case, the term "cost disease" might be misplaced because the outcome, i.e., a reallocation of production factors from the more productive sector to the less productive sector, is optimal from the perspective of a representative utility-maximizing household. Of course, this does not necessarily mean that spending an ever-larger fraction of income and production factors on healthcare is always optimal from a welfare perspective. Nonetheless, our model highlights that the intuition that reallocating production factors from the relatively more productive sector to the relatively less productive sector is inefficient or constitutes a "disease", as it will lower overall physical output, is not a priori correct and thus does not directly warrant government intervention.

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A Theory Appendix

A.1 Proof of Proposition 1 and 2

The effect of an increase in $A_{1,t}$ on p_t is given as

$$\frac{\partial p_t}{\partial A_{1,t}} = \frac{\begin{vmatrix} -\frac{\partial F}{\partial A_{1,t}} & \frac{\partial F}{\partial L_{1,t}} \\ -\frac{\partial G}{\partial A_{1,t}} & \frac{\partial G}{\partial L_{1,t}} \end{vmatrix}}{\begin{vmatrix} \frac{\partial F}{\partial p_t} & \frac{\partial F}{\partial L_{1,t}} \\ \frac{\partial G}{\partial p_t} & \frac{\partial G}{\partial L_{1,t}} \end{vmatrix}} > 0.$$

The effect on an increase in $H_{1,t}/A_{1,t}$ on $L_{1,t}$ is given as

$$\frac{\partial L_{1,t}}{\partial H_{1,t}} = \frac{\begin{vmatrix} \frac{\partial F}{\partial p_t} & -\frac{\partial F}{\partial H_{1,t}} \\ \frac{\partial G}{\partial p_t} & -\frac{\partial G}{\partial H_{1,t}} \end{vmatrix}}{\begin{vmatrix} \frac{\partial F}{\partial p_t} & \frac{\partial F}{\partial L_{1,t}} \\ \frac{\partial G}{\partial p_t} & \frac{\partial G}{\partial L_{1,t}} \end{vmatrix}} = \frac{\partial L_{1,t}}{\partial H_{1,t}} = \frac{\partial L_{1,t}}{\partial A_{1,t}} \begin{cases} > 0 & \text{if } \theta > 1, \\ < 0 & \text{if } \theta < 1, \\ = 0 & \text{if } \theta = 1. \end{cases}$$

The effect on an increase in $H_{2,t}/A_{2,t}$ on $L_{1,t}$ is given as

$$\frac{\partial L_{1,t}}{\partial H_{2,t}} = \frac{\begin{vmatrix} \frac{\partial F}{\partial p_t} & -\frac{\partial F}{\partial H_{2,t}} \\ \frac{\partial G}{\partial p_t} & -\frac{\partial G}{\partial H_{2,t}} \end{vmatrix}}{\begin{vmatrix} \frac{\partial F}{\partial p_t} & \frac{\partial F}{\partial L_{1,t}} \\ \frac{\partial G}{\partial p_t} & \frac{\partial G}{\partial L_{1,t}} \end{vmatrix}} = \frac{\partial L_{1,t}}{\partial H_{2,t}} = \frac{\partial L_{1,t}}{\partial A_{2,t}} \begin{cases} < 0 & \text{if } \theta > 1, \\ > 0 & \text{if } \theta < 1, \\ = 0 & \text{if } \theta = 1. \end{cases}$$

The effect of an increase in γ, i.e., the preference for good one, on p_t and $L_{1,t}$ is given as

$$\frac{\partial p_t}{\partial \gamma} = \frac{\begin{vmatrix} -\frac{\partial F}{\partial \gamma} & \frac{\partial F}{\partial L_{1,t}} \\ -\frac{\partial G}{\partial \gamma} & \frac{\partial G}{\partial L_{1,t}} \end{vmatrix}}{\begin{vmatrix} \frac{\partial F}{\partial p_t} & \frac{\partial F}{\partial L_{1,t}} \\ \frac{\partial G}{\partial p_t} & \frac{\partial G}{\partial L_{1,t}} \end{vmatrix}} < 0, \quad \frac{\partial L_{1,t}}{\partial \gamma} = \frac{\begin{vmatrix} \frac{\partial F}{\partial p_t} & -\frac{\partial F}{\partial \gamma} \\ \frac{\partial G}{\partial p_t} & -\frac{\partial G}{\partial \gamma} \end{vmatrix}}{\begin{vmatrix} \frac{\partial F}{\partial p_t} & \frac{\partial F}{\partial L_{1,t}} \\ \frac{\partial G}{\partial p_t} & \frac{\partial G}{\partial L_{1,t}} \end{vmatrix}} > 0.$$

If households have a higher preference for good 1, then the relative price of good 2 will fall and more low-skilled labor will flow into Sector 1.

Recall, from Section 2.3, that the equilibrium can be characterized as follows

$$\begin{aligned} F \equiv & p_t^{\theta} \frac{Y_{2,t}}{Y_{1,t}} - \frac{1}{\gamma} + 1 = 0, \\ G \equiv & \alpha_1 \frac{Y_{1,t}}{L_{1,t}} - p_t \alpha_2 \frac{Y_{2,t}}{L_{2,t}} = 0, \end{aligned}$$

$$\begin{aligned} &\frac{\partial F}{\partial p_t} > 0, \quad \frac{\partial F}{\partial L_{1,t}} < 0, \quad \frac{\partial F}{\partial H_{1,t}} = \frac{\partial F}{\partial A_{1,t}} < 0, \quad \frac{\partial F}{\partial H_{2,t}} = \frac{\partial F}{\partial A_{2,t}} > 0, \quad \frac{\partial F}{\partial \gamma} > 0, \\ &\frac{\partial G}{\partial p_t} < 0, \quad \frac{\partial G}{\partial L_{1,t}} < 0, \quad \frac{\partial G}{\partial H_{1,t}} = \frac{\partial G}{\partial A_{1,t}} > 0, \quad \frac{\partial G}{\partial H_{2,t}} = \frac{\partial G}{\partial A_{2,t}} < 0, \quad \frac{\partial G}{\partial \gamma} = 0. \end{aligned}$$

$$\begin{vmatrix} \frac{\partial F}{\partial p_t} & \frac{\partial F}{\partial L_{1,t}} \\ \frac{\partial G}{\partial p_t} & \frac{\partial G}{\partial L_{1,t}} \end{vmatrix} = \frac{\partial F}{\partial p_t}\frac{\partial G}{\partial L_{1,t}} - \frac{\partial F}{\partial L_{1,t}}\frac{\partial G}{\partial p_t} < 0.$$

$$\begin{vmatrix} -\frac{\partial F}{\partial A_{1,t}} & \frac{\partial F}{\partial L_{1,t}} \\ -\frac{\partial G}{\partial A_{1,t}} & \frac{\partial G}{\partial L_{1,t}} \end{vmatrix} = \left(-\frac{\partial F}{\partial A_{1,t}}\right)\frac{\partial G}{\partial L_{1,t}} + \frac{\partial F}{\partial L_{1,t}}\frac{\partial G}{\partial A_{1,t}} < 0.$$

$$\begin{aligned}
\begin{vmatrix} \frac{\partial F}{\partial p_t} & -\frac{\partial F}{\partial H_{1,t}} \\ \frac{\partial G}{\partial p_t} & -\frac{\partial G}{\partial H_{1,t}} \end{vmatrix} =& \frac{\partial F}{\partial p_t}\left(-\frac{\partial G}{\partial H_{1,t}}\right) + \frac{\partial F}{\partial H_{1,t}}\frac{\partial G}{\partial p_t} \\
=& -\theta p_t^{\theta-1}\frac{Y_{2,t}}{Y_{1,t}}\alpha_1\frac{1}{L_{1,t}}\frac{\partial Y_{1,t}}{\partial H_{1,t}} + p_t^{\theta}\frac{Y_{2,t}}{Y_{1,t}}\frac{1}{Y_{1,t}}\frac{\partial Y_{1,t}}{\partial H_{1,t}}\alpha_2\frac{Y_{2,t}}{L_{2,t}} \gtreqless 0 \\
=& p_t\alpha_2\frac{Y_{2,t}}{L_{2,t}} - \theta\alpha_1\frac{Y_{1,t}}{L_{1,t}} \gtreqless 0 \\
=& \frac{p_t\alpha_2\frac{Y_{2,t}}{L_{2,t}}}{\alpha_1\frac{Y_{1,t}}{L_{1,t}}} - \theta \gtreqless 0 \\
=& 1 - \theta \gtreqless 0.
\end{aligned}$$

$$\begin{aligned}
\begin{vmatrix} \frac{\partial F}{\partial p_t} & -\frac{\partial F}{\partial H_{2,t}} \\ \frac{\partial G}{\partial p_t} & -\frac{\partial G}{\partial H_{2,t}} \end{vmatrix} =& \frac{\partial F}{\partial p_t}\left(-\frac{\partial G}{\partial H_{2,t}}\right) + \frac{\partial F}{\partial H_{2,t}}\frac{\partial G}{\partial p_t} \\
=& \theta p_t^{\theta-1}\frac{Y_{2,t}}{Y_{1,t}}p_t\alpha_2\frac{1}{L_{1,t}}\frac{\partial Y_{2,t}}{\partial H_{2,t}} - p_t^{\theta}\frac{1}{Y_{1,t}}\frac{\partial Y_{2,t}}{\partial H_{2,t}}\alpha_2\frac{Y_{2,t}}{L_{2,t}} \gtreqless 0 \\
=& \theta - 1 \gtreqless 0.
\end{aligned}$$

A.2 Proof of Proposition 3

Let ξ_t denotes the share of good 1 in nominal GDP

$$\xi_t = \frac{Y_{1,t}}{Y_{1,t} + p_t Y_{2,t}}.$$

There are three channels through which an increase in $A_{1,t}$ can influence ξ in this model. First, directly by increasing the output produced in Sector 1. Second, by triggering a reallocation of low-skilled labor from one sector to the other. Third, by influencing the relative price of good 2 and thus affecting the nominal value of output produced in Sector 2.

We assume first that low-skilled labor cannot switch sectors. This simplifies the analysis, as we only have one equilibrium condition in this case

$$p_t = \left(\frac{1-\gamma}{\gamma} \frac{Y_{1,t}}{Y_{2,t}} \right)^{\frac{1}{\theta}}.$$

$$\begin{aligned}
\frac{\partial p_t}{\partial A_{1,t}} &= \frac{1}{\theta} \left(\frac{1-\gamma}{\gamma} \frac{Y_{1,t}}{Y_{2,t}} \right)^{\frac{1}{\theta}} \frac{1}{Y_{1,t}} \frac{\partial Y_{1,t}}{\partial A_{1,t}} \\
\frac{\partial p_t}{\partial A_{1,t}} &= \frac{1}{\theta} p_t \frac{1}{Y_{1,t}} \frac{\partial Y_{1,t}}{\partial A_{1,t}}.
\end{aligned}$$

$$\begin{aligned}
\frac{\partial \xi_t}{\partial A_{1,t}} &= \frac{\frac{\partial Y_{1,t}}{\partial A_{1,t}} p_t Y_{2,t} - Y_{1,t} \frac{\partial p_t}{\partial A_{1,t}} Y_{2,t}}{(Y_{1,t} + p_t Y_{2,t})^2} \gtreqless 0 \\
\frac{\partial \xi_t}{\partial A_{1,t}} &= \frac{\frac{p_t Y_{1,t} Y_{2,t}}{A_{1,t}} \left(\frac{\partial Y_{1,t}}{\partial A_{1,t}} \frac{A_{1,t}}{Y_{1,t}} - \frac{\partial p_t}{\partial A_{1,t}} \frac{A_{1,t}}{p_t} \right)}{(Y_{1,t} + p_t Y_{2,t})^2} \gtreqless 0 \\
\frac{\partial \xi_t}{\partial A_{1,t}} &= \frac{\frac{\partial Y_{1,t}}{\partial A_{1,t}} p_t Y_{2,t} - Y_{1,t} \frac{1}{\theta} p_t \frac{1}{Y_{1,t}} \frac{\partial Y_{1,t}}{\partial A_{1,t}} Y_{2,t}}{(Y_{1,t} + p_t Y_{2,t})^2} \gtreqless 0 \\
\frac{\partial \xi_t}{\partial A_{1,t}} &= \frac{\left(\frac{\partial Y_{1,t}}{\partial A_{1,t}} p_t Y_{2,t} \right) \left(1 - \frac{1}{\theta}\right)}{(Y_{1,t} + p_t Y_{2,t})^2} \gtreqless 0.
\end{aligned}$$

$$\frac{\partial \xi_t}{\partial A_{1,t}} \begin{cases} < 0 & \text{if } \theta < 1, \\ > 0 & \text{if } \theta > 1, \\ = 0 & \text{if } \theta = 1. \end{cases}$$

If the two goods are substitutes an increase in $A_{1,t}$ leads to an increase of good 1 as a share of nominal GDP. Consequently, for $\theta < 1$, i.e., the two goods are complements, an increase in $A_{1,t}$ leads to an increase in the share of good 2 in nominal GDP.

In case low-skilled labor is fully mobile, the effect of $A_{1,t}$ on ξ_t is given as

$$\frac{\partial \xi_t}{\partial A_{1,t}} = \left(p_t \frac{\partial L_{1,t}}{\partial A_{1,t}} \left(Y_{2,t} \frac{\partial Y_{1,t}}{\partial L_{1,t}} - Y_{1,t} \frac{\partial Y_{2,t}}{\partial L_{1,t}} \right) + \frac{p_t Y_{1,t} Y_{2,t}}{A_{1,t}} \left(\frac{\partial Y_{1,t}}{\partial A_{1,t}} \frac{A_{1,t}}{Y_{1,t}} - \frac{\partial p_t}{\partial A_{1,t}} \frac{A_{1,t}}{p_t} \right) \right) \cdot \frac{1}{(Y_{1,t} + p_t Y_{2,t})^2}$$

$$\frac{\partial \xi_t}{\partial A_{1,t}} = \left(\underbrace{p_t \frac{\partial L_{1,t}}{\partial A_{1,t}}}_{\gtreqless 0} \underbrace{\left(Y_{2,t} \frac{\partial Y_{1,t}}{\partial L_{1,t}} - Y_{1,t} \frac{\partial Y_{2,t}}{\partial L_{1,t}} \right)}_{>0} + \frac{p_t Y_{1,t} Y_{2,t}}{A_{1,t}} \underbrace{\left((1-\alpha_1) - \underbrace{\frac{\partial p_t}{\partial A_{1,t}} \frac{A_{1,t}}{p_t}}_{>0} \right)}_{\gtreqless 0} \right) \cdot \frac{1}{(Y_{1,t} + p_t Y_{2,t})^2} \gtreqless 0.$$

The first term captures the effect of the reallocation of low-skilled labor that follows the increase in $A_{1,t}$. Depending on the elasticity of substitution this term can be positive or negative. The second term consists of two elements with opposite signs. The first part captures the increase in output in Sector 1 due to the increase in $A_{1,t}$ and is thus positive. The second part, which is the same as in the case when low-skilled labor is immobile, captures the effect of the increase in $A_{1,t}$ on the relative price. It has a negative effect on ξ_t because an increase in $A_{1,t}$ makes good 1 relative more abundant to good 2 and this will increase the relative price of good 2, i.e., good 2 becomes more expensive and good 1 less expensive.

Assume $\alpha_1 = \alpha_2 = \alpha$, this entails that we can combine the equilibrium conditions and solve for p_t, which is given as

$$p_t = \left(\frac{1-\gamma}{\gamma} \right)^{\frac{1-\alpha}{\alpha+\theta(1-\alpha)}} \left(\frac{A_{2,t} H_{2,t}}{A_{1,t} H_{2,t}} \right)^{\frac{1-\alpha}{\alpha+\theta(1-\alpha)}}.$$

Using this, we can express $\frac{\partial p_t}{\partial A_{1,t}} \frac{A_{1,t}}{p_t}$ as

$$\frac{\partial p_t}{\partial A_{1,t}} \frac{A_{1,t}}{p_t} = \frac{1-\alpha}{\alpha + \theta(1-\alpha)}.$$

The sign of the second term of $\frac{\partial \xi_t}{\partial A_{1,t}}$ is determined by

$$\alpha + \theta(1-\alpha) - 1 \gtreqless 0,$$

which is zero for $\theta = 1$, smaller than zero for $\theta \in (0,1)$, and larger than zero for $\theta > 1$.

Proof. For $\theta = 0$, we have $\alpha - 1 < 0$, as $\alpha \in (0,1)$. For $\theta = 1$, we have $1 - 1 = 0$. As $\alpha + \theta(1-\alpha) - 1$ is strictly increasing in θ it follows that for $\theta \in (0,1)$, $\alpha + \theta(1-\alpha) - 1 < 0$ and for $\theta > 1$, $\alpha + \theta(1-\alpha) - 1 > 0$. □

Therefore, it follows that an increase in $A_{1,t}$ has the following effect on the share of Sector 1 in nominal GDP

$$\frac{\partial \xi_t}{\partial A_{1,t}} \begin{cases} < 0 & \text{if } \theta < 1, \\ > 0 & \text{if } \theta > 1, \\ = 0 & \text{if } \theta = 1. \end{cases}$$

A.3 Full Factor Mobility

Consider a situation in which all production factors are fully mobile, except for the level of technology. For simplicity we assume each sector only produces with one production factor, but the production function has constant returns to scale in that factor. The production function for good j with $j \in \{1,2\}$ is given as

$$Y_{j,t} = A_{j,t} L_{j,t}.$$

The equilibrium can again be characterized by a system of two equations

$$
\begin{aligned}
F \equiv & p_t^{\theta} \frac{A_{2,t}(L_t - L_{1,t})}{A_{1,t} L_{1,t}} - \frac{1-\gamma}{\gamma} = 0 \\
F \equiv & p_t^{\theta} \frac{Y_{2,t}}{Y_{1,t}} - \frac{1}{\gamma} + 1 = 0, \\
G \equiv & w_{1,t}^{l} - w_{2,t}^{l} = 0 \\
G \equiv & A_{1,t} - p_t A_{2,t} = 0 \\
G \equiv & \frac{Y_{1,t}}{L_{1,t}} - p_t \frac{Y_{2,t}}{L_{2,t}} = 0.
\end{aligned}
$$

This entails

$$
\begin{aligned}
&\frac{\partial F}{\partial p_t} > 0, \quad \frac{\partial F}{\partial L_{1,t}} < 0, \quad \frac{\partial F}{\partial A_{1,t}} < 0, \quad \frac{\partial F}{\partial A_{2,t}} > 0, \quad \frac{\partial F}{\partial \gamma} > 0, \\
&\frac{\partial G}{\partial p_t} < 0, \quad \frac{\partial G}{\partial L_{1,t}} = 0, \quad \frac{\partial G}{\partial A_{1,t}} > 0, \quad \frac{\partial G}{\partial A_{2,t}} < 0, \quad \frac{\partial G}{\partial \gamma} = 0.
\end{aligned}
$$

And therefore, the results of the comparative statics are the same as in Section A.1.

A.4 Heterogeneous Preferences

Assume households face the same maximization problem as before, except now preferences over the two goods are heterogeneous, i.e., γ^i can now potentially differ across groups. To simplify the analysis, we further assume that all labor is immobile, i.e., low-skilled workers cannot switch sectors. This allows us to express the equilibrium as one equation.

$$
\begin{aligned}
&\max_{c_{1,t}^i, c_{2,t}^i} c_t^i(c_{1,t}^i, c_{2,t}^i) = \left((\gamma^i)^{\frac{1}{\theta}} (c_{1,t}^i)^{\frac{\theta-1}{\theta}} + (1-\gamma^i)^{\frac{1}{\theta}} (c_{2,t}^i)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \quad i \in \{e, d, l\} \\
&\text{s.t. } c_{1,t}^i + p_t c_{2,t}^i = I_t^i
\end{aligned}
$$

with $\theta \in (0, \infty)$.

Market clearing requires

$$\begin{aligned}
\frac{Y_{2,t}}{Y_{1,t}} =& \frac{\sum_i (1-\gamma^i) p_t^{-\theta} \frac{I_t^i}{\gamma^i + (1-\gamma^i) p_t^{1-\theta}} N_t^i}{\sum_i \gamma^i \frac{I_t^i}{\gamma^i + (1-\gamma^i) p_t^{1-\theta}} N_t^i} \\
p_t^\theta \frac{Y_{2,t}}{Y_{1,t}} =& \frac{\sum_i (1-\gamma^i) \frac{I_t^i}{\gamma^i + (1-\gamma^i)} N_t^i}{\sum_i \gamma^i \frac{I_t^i}{\gamma^i + (1-\gamma^i)} N_t^i} \\
p_t^\theta \frac{Y_{2,t}}{Y_{1,t}} =& \frac{\sum_i (1-\gamma^i) I_t^i N_t^i}{\sum_i \gamma^i I_t^i N_t^i} \\
p_t^\theta \frac{Y_{2,t}}{Y_{1,t}} =& \frac{\sum_i \mathcal{I}_t^i (Y_{1,t}, Y_{2,t}, p_t)}{\sum_i \gamma^i \mathcal{I}_t^i (Y_{1,t}, Y_{2,t}, p_t)} - 1,
\end{aligned}$$

where $\mathcal{I}_t^i(Y_{1,t}, Y_{2,t}, p_t) = I_t^i N_t^i$ denotes the aggregate income of group i.

The case of homogeneous preferences can be derived by assuming γ^i is the same for all groups.[25]

$$F \equiv p_t^\theta \underbrace{\frac{Y_{2,t}}{Y_{1,t}}}_{\text{relative supply}} - \underbrace{\frac{Y_{1,t} + p_t Y_{2,t}}{\sum_i \gamma^i \mathcal{I}_t^i (Y_{1,t}, Y_{2,t}, p_t)}}_{\text{demand composition}} + 1,$$

where we use the fact that $\sum_i \mathcal{I}_t^i(Y_{1,t}, Y_{2,t}, p_t) = Y_{1,t} + p_t Y_{2,t}$. A change in $Y_{j,t}$ with $j \in \{1,2\}$ has an effect on the relative price p_t through the relative supply as well as by altering the demand composition. The latter channel only exists in a model with heterogeneous preferences.

[25] This yields $p_t^\theta \frac{Y_{2,t}}{Y_{1,t}} = \frac{1}{\gamma} - 1$.

B General Appendix

B.1 List of Countries

Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Türkiye, United Kingdom, United States

B.2 Employment in the Healthcare Sector in Germany

This section details some of the particularities of employment in the health sector in Germany. Self-employment is quite common in the health sector in Germany. In 2012, 4.7% of all self-employed in Germany were physicians and pharmacists, making it the occupational group with the fifth most self-employed persons (see Mai and Marder-Puch (2013), p. 490, only available in German). The income of self-employed persons in general is difficult to pin down. Nevertheless, the net income of self-employed physicians' offices in Germany in 2015 is reported to have been €192,000.[26] In comparison, employed physicians earned between €57,000 and €125,000 in 2019, according to the relevant collective labor agreement.[27] Given these numbers, it seems likely that physicians earn even more than suggested in the employment data. Thus the skill premium and its increase over the year is likely underestimated in the employment data.

[26] This is according to the Statistische Bundesamt, Fachserie 2 Reihe 1.6.1, p.19, only available in German. For a short link see https://t.ly/BTkRI

[27] See: https://www.marburger-bund.de/bundesverband/tarifvertraege

B.3 German Labor Force Changes 2007-2018

Table 7 and Table 8 display changes in the German labor force, analogously to Tables 5 and 6 in Section 3.2.2. They display the same statistics and ratios using German data. The goal is to facilitate the comparison of results found in the German and US data. Deviating from the US data, workers with medium skill levels are counted towards unskilled workers, such that the share of the unskilled labor force both in the overall economy and the health sector is larger in Table 7 than in Table 5. This however is irrelevant to the derived results, as the focus of the analysis is on relative, rather than absolute changes in labor force shares.

Table 7: *German Labor Force Changes 2007-2018*

	Overall Economy		Health Sector	
	2007	2018	2007	2018
Unskilled Labor Force	64.7%	64.7%	57.5%	60.3%
Δ		0%		+4.9%
Skill Premium	1.75	1.83	1.79	1.96
Δ		+4.6%		+9.1%

Note: Calculations based on data from the German Statistical Office.

Table 8: *German Ratios of Key Indicators*

	2007	2018
Unskilled Labor Force Ratio	0.889	0.932
Skill Premium Ratio	1.023	1.071

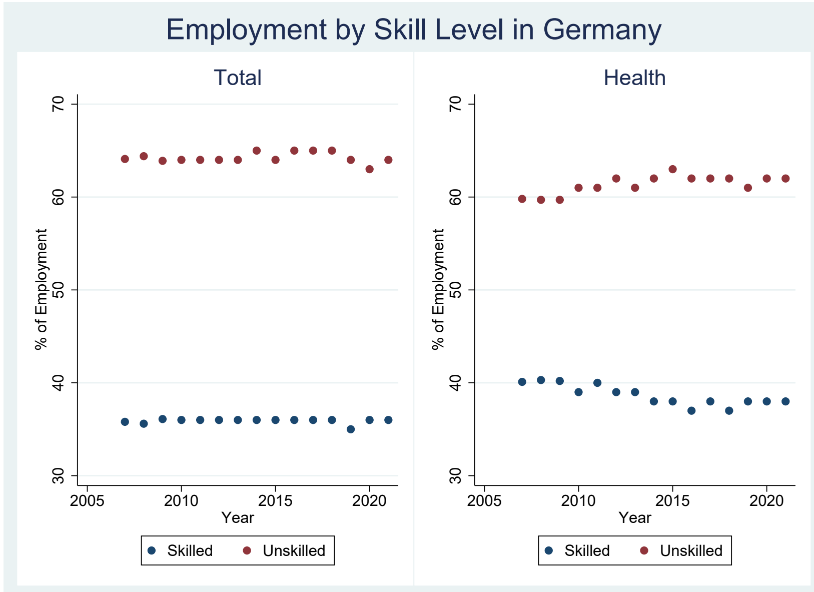
Note: Calculations based on Table 7, which summarizes data from the German Statistical Office. The ratios implicitly account for time trends and compositional changes in the labor force.

B.4 Additional Graphs

This figure provides a graphical illustration of the trend in employment and expenditure in the health sector in Germany, based on data provided by the OECD

Figure 4: *Employment and Expenditure in the Health Sector*

Figure 4 illustrates the share of employment in the health sector as well as the share of overall expenditure going towards healthcare in Germany. Both measures have been continually on the rise in absolute as well as relative terms.



This figure provides a graphical illustration of the trend in the employment shares of skilled and unskilled workers in the overall economy and the health sector in Germany. The data used are provided by the German Statistical Office. Workers are classified as skilled if they are university graduates and unskilled otherwise.

Figure 5: *The Share of Skilled and Unskilled Employment in Germany*

Figure 5 illustrates the share of high- and low skilled labor for the total economy and the health sector in Germany from 2007 to 2018. While there is little to no change in the total economy, there is a slight upward trend for low skilled labor in the health sector. The left panel of Figure 5 is in stark contrast to Figure 3 depicting the case of the US, which saw a marked increase in the share of high skilled labor. No figure equivalent to the right panel of Figure 5 exists for the US, due to a lack of available data.