Elasticity of substitution between labor and capital: robust evidence from developed economies*

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Abstract

This paper provides estimates of the aggregate elasticity of substitution between labor and capital (σ) in developed economies. Our empirical strategy consists in estimating two- and three-equation supply-side systems which combine a normalized CES production function and first order conditions for factors of production. Using a panel of 12 advanced economies between 1980 and 2006, it is found that capital and labor are gross complements and σ is on average around 0.7. Moreover, we also document net labor-augmenting technical progress. Our main findings remain robust to various assumptions on time-varying factor-augmenting technical change. Furthermore, we replicate the benchmark results with two alternative datasets. To strengthen these findings a systematic evidence of capital-labor substitution is provided at the country level. Although substantial cross-country variation in σ can be found, a wide range of estimates confirms that labor and capital are gross complements and technical change is net labor-augmenting.

Keywords: normalized CES production function, elasticity of substitution between labor and capital, factor-augmenting technical change, factor shares.

JEL Classification Numbers: C22, C23, E23, E25, O47.

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1 Introduction

The elasticity of substitution between labor and capital (σ) is one of the key characteristics of supply side of the economy. As it has been synthesized by Klump et al. (2012), it plays crucial role in many fields of economics, e.g., economic growth, labor market and public finance. For instance, high values of σ, i.e., above unity, might be perceived as an engine of perpetual growth because then the scarce factor can be easily substituted by the abundant one.

A natural environment to study σ is the Constant Elasticity of Substitution (henceforth, CES) production function which was introduced by Arrow et al. (1961). When the elasticity of substitution equals unity then the CES production function nests the Cobb-Douglas form which persists almost as a paradigm in modern macroeconomic modelling. A critical value of σ is unity. If elasticity of substitution is above (below) unity then factors are gross substitutes (complements).

The magnitude of the elasticity of substitution is important for understanding trend in factor shares or, more generally, income inequality. Since Kaldor (1957) has formulated his famous *stylized facts* a conventional wisdom in macroeconomics is that the labor and capital share are stable over time. This fact motivates the Cobb-Douglas aggregate production function assumption. However, Arpaia et al. (2009) and Karabarbounis and Neiman (2014) document a secular downward tendency of the labor share in advanced economies since the 1970s. Moreover, based on long US time series Growiec et al. (2015) identify a hump-shaped long-run trajectory. These empirical regularities can explained be jointly by non-unitary elasticity of substitution and factor-augmenting technical change (Acemoglu, 2003).

Empirical identification of the elasticity of substitution between labor and capital has challenged and fascinated many researchers. In their pioneering article, Arrow et al. (1961) find that σ is below 0.6 in the United States over the period from 1909 to 1949. Later studies for the aggregate US economy have also documented gross complementarity between labor and capital (Antràs, 2004; Klump et al., 2007). Furthermore, the hypothesis that the elasticity of substitution is below unity is also supported by empirical evidence at the sectoral (Young, 2013; Herrendorf et al., 2015) and at the firm level (Oberfield and Raval, 2014). In the context of DSGE (dynamic stochastic general equilibrium) modelling, Cantore et al. (2015) show that the scenario with σ below unity fits overwhelmingly better to the US economy than Cobb-Douglas form.

Although there are numerous papers documenting that σ is below unity for the US studies exploiting cross-country variation provide contradictory estimates of σ. Using a panel for 82 countries over 28 years, Duffy and Papageorgiou (2000) find that the elasticity of substitution is on average above unity. More recently, empirical evidence provided by Karabarbounis and Neiman (2014) implies that σ is about 1.25. This leaves some puzzle which seems to be unresolved.

In this paper, we attempt to shed new light on this puzzle. Using a panel for 12 economies over 27 years we aim to provide robust estimates of the elasticity of substitution for advanced economies. There are at least two reasons that motivate the above choice. The first criterion is the availability of long-dated series on product, inputs and their prices. Secondly, empirical studies allowing for cross-country variation in σ document that this heterogeneity might be non-negligible (Duffy and Papageorgiou, 2000; Mallick, 2012). From these reasons, our research focus is concentrated only on advanced economies.

Our empirical strategy is as follows. Given the recent developments from the literature on normalized CES production function (Klump et al., 2012), we consider two- and three-equation supply-side systems which combine this form of aggregate production function with the standard first order conditions for the production factors. As pointed by León-Ledesma et al. (2010), apart from intuitive boost in efficiency, joint system estimation outperforms standard single-equations approaches in terms of capturing deep production and technology parameters. We also relax the standard assumption that technical progress is Hicks-neutral in order to fit more flexible patterns of factor-augmenting efficiency trends.

The main contribution of this paper to the literature is to provide robust evidence on the magnitude of the elasticity of substitution. Our baseline results imply that labor and capital are gross complements and a wide range of estimates indicates that σ is about 0.7 in developed countries. Furthermore, net labor-augmenting technical change is broadly documented. Apart from the theory-consistent growth in labor-augmenting technical progress our comprehensive evidence documents a downward trend in unobserved capital-augmenting efficiency.

The above findings pass a number of robustness tests. Firstly, we extensively investigate the pattern of factor-augmenting technical change. In particular we consider (i) an abrupt break in the growth rates of factor augmentation, (ii) the Box-Cox transformation, (iii) time dummies, and (iv) a trigonometric representation approximating smooth structural breaks. Secondly, we also examine whether our benchmark results are sensitive to presence of aggregate markups. Thirdly, we use two alternative dataset in order to check whether it is possible to replicate the documented production characteristics. All above robustness checks do not alter our main findings.

Finally, our empirical evidence at the country level confirms gross complementarity between labor and capital. Despite a substantial variation in the estimates of σ across advanced economies, gross complementarity between labor and capital can be found in all of the cases. Importantly, even when we carefully take into account potentially non-linear patterns of factor-augmenting technical change, then the below unitary elasticity of substitution remarks very close to our baseline results.

In the current study we focus mostly on time variation. Due to normalization we abstract from systematic cross-country level differences in factor endowments. Thus, our estimates are able to explain the recent trends in factor shares. According to the documented production characteristics, the recent decline in the labor share cannot be associated with physical capital accumulation since labor and capital are gross complementary, i.e., $\sigma < 1$. Under gross complementarity, factor-augmenting technical progress is the dominant process that explains the direction of recent trends in factor shares.

The structure of the paper is as follows. Section 2 introduces panel normalized supply-side system estimation. Section 3 discusses the data and their properties. In section 4, our baseline results are presented. The robustness of main production characteristics is broadly checked in section 5. Section 6 provides comprehensive empirical evidence for fundamental production characteristics at the country level. Finally, section 7 concludes.

2 The normalized CES production function

In this section we introduce a panel approach that allows us to identify the elasticity of substitution between labor and capital. Consider the following normalized CES production function:

$$Y_{it} = F\left(K_{it}, L_{it}, \Gamma^{\mathcal{K}}_{it}, \Gamma^{\mathcal{L}}_{it}\right) = Y_{i0}\left[\pi_{i0}\left(\Gamma^{\mathcal{K}}_{it}\frac{K_{it}}{K_{i0}}\right)^{\frac{\sigma-1}{\sigma}} + (1-\pi_{i0})\left(\Gamma^{\mathcal{L}}_{it}\frac{L_{it}}{L_{i0}}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{1-\sigma}}, \quad (1)$$

where Y_{it} is the real output, K_{it} and L_{it} stand for the capital stock and the labor input, respectively. The parameter π_{0i} denotes the capital share at the point of normalization. The expressions $\Gamma^{\mathcal{K}}_{it}$ and $\Gamma^{\mathcal{L}}_{it}$ represent the capital- and labor-augmenting technical progress, respectively. The index i denotes unit in a panel, i.e., country. Finally, the parameter σ stands for the elasticity of substitution between labor and capital. In general, the σ is defined as the elasticity of changes in factor proportion (K_{it}/L_{it}) in reaction to a change in the marginal rate of technical substitution:

$$\sigma = \frac{d\ln\left(K/L\right)}{d\ln\left(F_L/F_K\right)}, \quad (2)$$

where $F_L = \partial F/\partial L$ and $F_L = \partial F/\partial K$.

The normalized CES production function nests other functional forms of the aggregate production function. Note that (1) converges to the Cobb-Douglas function as $\sigma \to 1$, to a Leontief function with fixed factor proportions as $\sigma \to 0$ and to a linear function when σ tends to ∞. In intermediate case, factors of production are gross complements (substitutes) if σ is below (above) unity.

Contrary to standard approach exploiting the normalized CES production function for a single country (Klump et al., 2012), it is assumed that each unit of panel has different normalization points, i.e., Y_{i0}, K_{i0}, L_{i0} and π_{i0} varies over i. This strategy seems to be attractive because it allows us to control unobserved heterogeneity in the long-run properties of economies across countries included in panel.

Under the assumption of the CES production function (1), the standard profit maximization yields to the following first order conditions:

$$r_{it} = \frac{\partial Y_{it}}{\partial K_{it}} = \pi_{i0}\left(\frac{Y_{i0}}{K_{i0}}\Gamma^{\mathcal{K}}_{it}\right)^{\frac{\sigma}{1-\sigma}}\left(\frac{Y_{it}}{K_{it}}\right)^{\frac{1}{\sigma}} \quad (3)$$

$$w_{it} = \frac{\partial Y_{it}}{\partial L_{it}} = (1-\pi_{i0})\left(\frac{Y_{i0}}{L_{i0}}\Gamma^{\mathcal{L}}_{it}\right)^{\frac{\sigma}{1-\sigma}}\left(\frac{Y_{it}}{L_{it}}\right)^{\frac{1}{\sigma}} \quad (4)$$

where r_{it} and w_{it} stand for the user cost of capital and labor, respectively. The above conditions imply that the relative factor income share is given by:

$$\Theta_{it} = \frac{r_{it}K_{it}}{w_{it}L_{it}} = \frac{\pi_{i0}}{1-\pi_{i0}}\left(\frac{\Gamma^{\mathcal{K}}_{it}}{\Gamma^{\mathcal{L}}_{it}}\frac{K_{it}}{K_{i0}}\frac{L_{i0}}{L_{it}}\right)^{\frac{\sigma-1}{\sigma}}. \quad (5)$$

The above expression for capital-to-labor income highlights the essential role of the elasticity of substitution as well as the factor-augmenting technical change in the dynamics of factor share. Note that if a Cobb-Douglas view of economy is true $(\sigma = 1)$ then any change in (relative) factor-augmenting technical change or capital-labor ratio will not drive the factor shares and, as a result, these macroeconomic variables will be stable over time. Otherwise, the factor share might display some persistence. For instance, the recent decline in the labor share can be explained by fall in capital per worker or/and rise in labor-saving technical progress if factors are gross complements, i.e., $\sigma < 1$.

Finally, our estimation strategy consists in the first-order maximization conditions and the normalized CES production function in the log form:

$$\ln\left(\frac{Y_{it}}{Y_{0t}}\right) = \ln(\xi) + \frac{\sigma}{1-\sigma}\ln\left[\pi_{i0}\left(\Gamma^{\mathcal{K}}_{it}\frac{K_{it}}{K_{i0}}\right)^{\frac{1-\sigma}{\sigma}} + (1-\pi_{i0})\left(\Gamma^{\mathcal{L}}_{it}\frac{L_{it}}{L_{i0}}\right)^{\frac{1-\sigma}{\sigma}}\right], \quad (6)$$

$$\ln\left(\frac{r_{it}K_{it}}{w_{it}L_{it}}\right) = \ln\left(\frac{\pi_{i0}}{1-\pi_{i0}}\right) + \frac{\sigma-1}{\sigma}\left[\ln\left(\frac{K_{it}}{K_{i0}}\right) - \ln\left(\frac{L_{it}}{L_{i0}}\right) + \ln\left(\frac{\Gamma^{\mathcal{K}}_{it}}{\Gamma^{\mathcal{L}}_{it}}\right)\right], \quad (7)$$

$$\ln\left(\frac{w_{it}L_{it}}{P_{Yit}Y_{it}}\right) = \ln\left(\frac{1-\pi_{i0}}{1+\mu}\right) + \frac{1-\sigma}{\sigma}\left(\ln\left(\frac{Y_{it}}{L_{it}}\frac{L_{i0}}{Y_{i0}}\right) - \ln(\xi) - \ln\left(\Gamma^{\mathcal{L}}_{it}\right)\right), \quad (8)$$

$$\ln\left(\frac{r_{it}K_{it}}{P_{Yit}Y_{it}}\right) = \ln\left(\frac{\pi_{i0}}{1+\mu}\right) + \frac{1-\sigma}{\sigma}\left(\ln\left(\frac{Y_{it}}{K_{it}}\frac{K_{i0}}{Y_{i0}}\right) - \ln(\xi) - \ln\left(\Gamma^{\mathcal{K}}_{it}\right)\right), \quad (9)$$

where P_{Yit} represents the price deflator for output, ξ is the constant whose the expected value is around unity and parameter μ captures an aggregate mark-up and under perfect competition μ equals zero.

Based on the above expressions we will consider the following estimation both single-equation approach and joint system estimation. First strategy consists in estimating the underlying parameters of each of the linear equations (7), (9) and (8). In the joint system estimation the linear equations for (relative) factors shares are combined with the non-linear CES production function (6). For a completeness, two systems will be considered (i) the two-equation using (6) together with (7), and three-equation combining (8), (9) and (6). The structural parameters will be estimated with an Iterated Feasible Generalized Nonlinear Least Squares estimator. This choice stems out from the fact that the residuals are expected to be correlated across equations.

Despite its nonlinear nature the system estimation offers some advantages in comparison to single approach (León-Ledesma et al., 2010). Prominent property of the system estimation is a fact that it incorporates cross-equation constraints. As a results, this increase in the degrees of freedom leads to a boost in estimation efficiency. Moreover, in single approach the production function is omitted and, therefore, identification of technical progress and elasticity of substitution might be substantially deteriorated. For these reasons, two-equation system using linear equations for factor shares, i.e., (8) and (9), is not appealing estimation form in the current study.

3 Data

Our data source is EU KLEMS database. This choice is motivated by several reasons. Firstly, the EU KLEMS offers long time series for many advanced economies. Secondly, it offers the data on output, capital labor and factor share which are comparable since methodology is common for various countries. Thirdly, the EU KLEMS provides quality-adjusted series of labor and capital services. It is especially important because most of advanced economies have witnessed the ongoing changes in labor and/or capital composition.

Given the above motivation for using the EU KLEMS database, the detailed construction of our variables is as follows. The real (nominal) output is measured as Gross Value Added in constant (current) prices. As regards, we use quality-adjusted series of labor and capital services in order to control the ongoing changes in composition of these factors. The labor (capital) share is calculated as a simple relation of labor (capital) compensation to nominal aggregate output. Two points should be mentioned here. Firstly, according to the EU KLEMS methodology, the remuneration of labor is adjusted by both changes in quality of the labor force and a number of self-employed.[1] Secondly, the factor shares sum to unity and, consequently, an aggregate mark-up could be ascribed to capital share.

For our baseline analysis, we use data for market economy instead of total economy. Market economy in the EU KLEMS excludes public administration, other non-market services and the real estate sector (O'Mahony and Timmer, 2009). This strategy is consistent with an empirical practice to reduce an aggregate economy by government and residential sectors (Klump et al., 2007). The reason for that is the measurement problem in these sectors of economy (see O'Mahony and Timmer, 2009, for a general discussion).

We also restrict the EU KLEMS dataset to have a balanced panel. This choice seems to be reasonable because we use the normalized CES production function and empirical estimates of the elasticity of substitution refer to normalization point(s). Thus, by using an unbalanced panel one might expect the substantial bias arising from an increased heterogeneity in the normalization points across countries.

With these restrictions, our baseline dataset covers the time span from 1980 and 2006 for 12 countries: Austria (abbreviated as AUT), Belgium, (BEL), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Italy (ITA), Japan (JPN), the Netherlands (NLD), Spain (ESP), the United Kingdom (GBR) and the United States (USA).

Figure 1 portrays the relative factor shares, i.e. capital to labor renumeration, in the developed countries in our sample. Eyeballing the data suggests a pronounced upward trend. This empirical pattern corresponds with the broadly documented decline in the labor share in developed economies since the 1970s (Arpaia et al., 2009; Karabarbounis and Neiman, 2014) or, more general with complex dynamics of the factor shares (Growiec et al., 2015; Mućk et al., 2015).

To corroborate our above visual inspection we move to panel stationarity tests. Table 1 reports the results of panel unit root tests as well as measures of cross-sectional dependence. Let us start with the cross-sectional dependence measure. For the factor shares as well as the relative factor shares the averaged absolute correlation exceeds 0.45. Intuitively, these numbers indicate non-negligible cross-sectional dependence. We also apply formal test statistics, denoted by $\mathcal{CD}$, proposed by Pesaran (2004).[2] The null about cross sectional independence is rejected at any reasonable significance level. The detected moderate cross-sectional dependence might be critical for testing a unit root. Thus, we use standard IPS test proposed Im et al. (2003) as well as CIPS test proposed by Pesaran

[1] For a general discussion of dealing with an ambiguous income earned by self-employed workers see Mućk et al. (2015).

[2] Under the null hypothesis of cross-section independence the $\mathcal{CD}$ statistic is normally distributed, i.e., $\mathcal{CD} \sim \mathcal{N}(0, 1)$.

Figure 1: Relative factor shares (deviation from country-specific average)

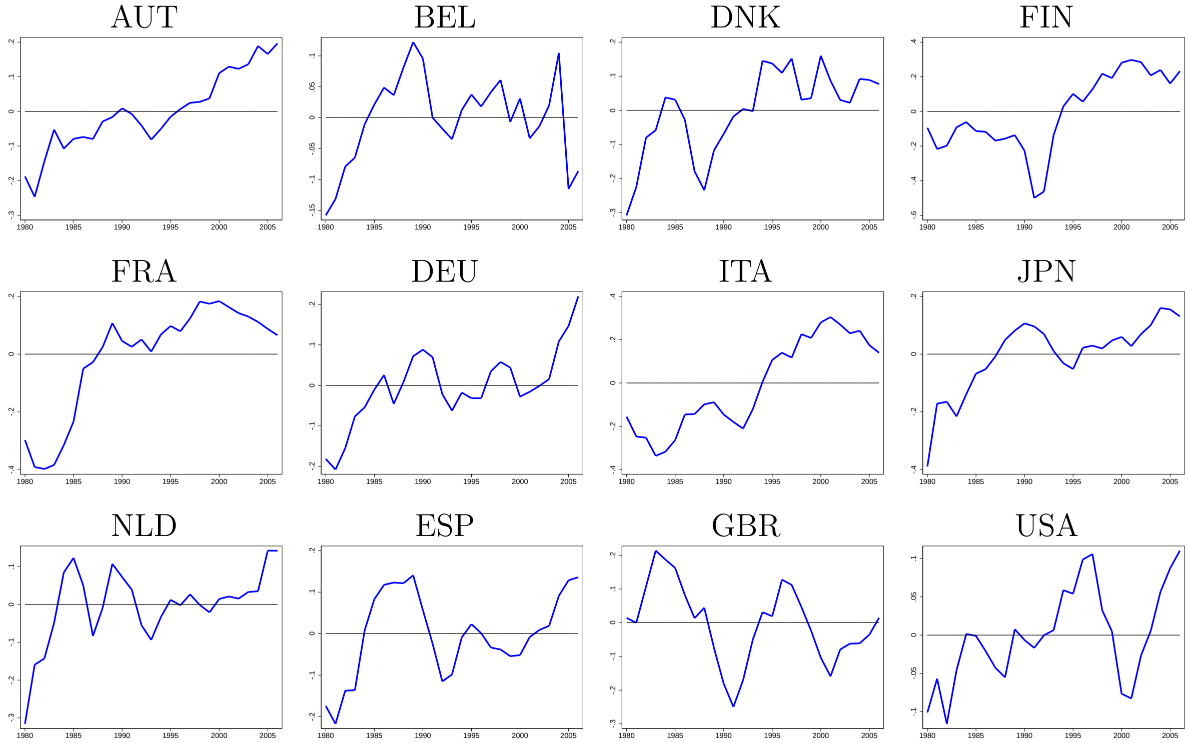


Table 1: Descriptive statistics

	Cross-sectional dependence			Panel Unit Root tests	
	avg ρ	avg $\lvert\rho\rvert$	$\mathcal{CD}$	IPS	CIPS
$(w_{it}L_{it})/(P_{Yit}Y_{it})$	0.398	0.468	16.780	[0.164]	[0.321]
$(r_{it}K_{it})/(P_{Yit}Y_{it})$	0.398	0.468	16.780	[0.164]	[0.321]
$\ln((r_{it}K_{it})/(w_{it}L_{it}))$	0.402	0.471	16.968	[0.107]	[0.220]
$\ln(K_{it}/L_{it})$	0.984	0.984	41.554	[0.991]	[0.651]
$\ln(Y_{it}/K_{it})$	0.720	0.720	30.378	[1.000]	[0.850]
$\ln(Y_{it}/L_{it})$	0.950	0.950	40.117	[0.994]	[0.519]

Note: avg ρ and avg $|\rho|$ stand for the averaged and the averaged absolute correlation coefficient, respectively. $\mathcal{CD}$ is the cross-sectional dependence test statistics. The expressions in squared brackets stand for probability values corresponding to null hypothesis about unit root tests.

(2007) which is designed to take into account cross-sectional dependence.[3] However, the corresponding probability values reported in table 1 do not allow us to reject the null about non-stationarity.

The last three rows of table 1 summarize main features of remaining variables. Intuitively, the (logged) labor productivity, the (logged) capital productivity and the (logged) capital-to-labor ratio are non-stationary and display substantial cross sectional dependence.

As regards, country-specific normalization points are assumed. Intuitively, it allows

[3]The null in both tests is about non-stationarity. The number of lags is determined by the BIC criterion. The reported numbers refer to the case with only constant since it is consistent with theoretical definition. But the inclusion of a linear trend in the respective test regression does not alter our findings.

us to control the heterogeneity in the long-run properties of economies included in panel. More precisely, our strategy to fixing the normalization points is quite standard, i.e., geometric averages are taken for non-stationary series (Y_{i0}, $K_{,0}$, L_{i0}) while arithmetic means are used for the capital shares (π_{i0}).[4]

4 Results

In this section, we provide baseline estimates of the elasticity of substitution between labor and capital in developed countries. In our benchmark specification, it is assumed that the rates of labor and capital augmentation, denoted by γ_{li} and γ_{ki}, are constant over time and varies between countries:

$$\Gamma_{it}^{j} = \exp\left(\gamma_{ji}\left(t - t_0\right)\right), \tag{10}$$

where $j \in \{L, K\}$, t_0 is the sample mean of t and $t \in \{1, \ldots, T\}$. All our panel estimation are conducted for two cases: (i) homogeneous growth rates of factor augmentation, i.e., $\gamma_{ji} = \gamma_j$, and (ii) heterogeneous γ_{ji}. The potential heterogeneity in γ_j will be captured by dummy variables.[5]

Let us start with the estimation results that based on single equation approach (table 2). The first-order conditions for factors of production deliver opposite estimates of σ. On the one hand, the equation for labor (8) predicts that factors are gross substitutes because the estimated σ exceeds unity. At the same time, the estimated growth rate of labor augmentation is surprisingly small (heterogeneous γ_l) or statistically insignificant (homogeneous γ_l). This means that the widely documented decline in the labor share can be directly explained by capital deepening while labor-biased technical change only limits its effect. On the other hand, the first-order condition for capital (9) implies that labor and capital are gross complements ($\sigma < 1$). Moreover, there is strong evidence in favor of negative capital augmentation. Although the decline in capital-augmenting unobserved efficiency is hardly interpretable this empirical regularity is consistent with some empirical studies for the US (Antràs, 2004; Growiec and Mućk, 2016). In accordance to these estimates, the explanation for the observed labor share decline (capital share rise) under below unitary elasticity is net labor-augmenting progress while physical capital accumulation limits this change.

The aforementioned inconsistency is resolved if one focuses on the equation for relative factors (7). According to these estimates the elasticity of substitution lies in a range given by above results but it is clearly below unity. Moreover, relatively fast pace of net labor-augmenting technical change ($\gamma_{l/k} = \gamma_l - \gamma_k \approx 0.065$) is straightforward to observe. This fact confirms indirectly the previous negative growth rates of capital augmentation. These characteristics imply that the decline in the labor share can be explained by labor-biased technology changes.

Table 3 presents the estimation results for two- and three-equations systems. Irrespectively of the system specification the estimated elasticity of substitution is unambiguously

[4] As discussed earlier, both capital and labor share display the pronounced trend in our sample. However, taking π_{i0} as geometric mean does not change our results. This finding is in line with the Monte Carlo results documented by León-Ledesma et al. (2015).

[5] For brevity, we will present only averaged estimated growth rates of the factor-augmenting technical change. Corresponding standard errors will be calculated with the delta method.

Table 2: Estimates of the elasticity of substitution - single equation approach

	Homogeneous γ			Heterogeneous γ_i		
	(8)	(9)	(7)	(8)	(9)	(7)
σ	1.182^{***}	0.708^{***}	0.752^{***}	1.547^{***}	0.553^{***}	0.771^{***}
	(0.050)	(0.031)	(0.044)	(0.117)	(0.048)	(0.126)
ξ	0.995^{***}	1.011^{***}		0.998^{***}	1.006^{***}	
	(0.011)	(0.010)		(0.004)	(0.004)	
γ_l	0.000			0.010^{***}		
	(0.005)			(0.001)		
γ_k		-0.032^{***}			-0.023^{***}	
		(0.003)			(0.002)	
$\gamma_{l/k}$			0.063^{***}			0.067^{***}
			(0.008)			(0.024)
$\mathcal{H}_0 : \sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.069]
$\mathcal{H}_0 : \gamma = \gamma_i$				[0.000]	[0.000]	[0.000]
Residuals diagnostics						
avg ρ	0.067	0.091	0.096	0.111	0.192	0.152
avg $\lvert\rho\rvert$	0.324	0.347	0.326	0.300	0.302	0.323
$\mathcal{CD}$	2.809	3.835	4.034	4.682	8.096	6.416
IPS	[0.104]	[0.135]	[0.107]	[0.003]	[0.000]	[0.001]
CIPS	[0.650]	[0.493]	[0.537]	[0.280]	[0.039]	[0.119]

Note: the superscripts ***, ** and * denote the rejection of null about parameters' insignificance at 1%, 5% and 10% significance level, respectively. The expressions in round and squared brackets stand for standard errors and probability values corresponding to respective hypothesis, respectively. The avg ρ and avg $|\rho|$ stand for the averaged and the averaged absolute correlation coefficient, respectively. $\mathcal{CD}$ is the cross-sectional dependence test statistics. In the panel stationarity test, i.e., IPS and CIPS, the null hypothesis is about unit root tests.

below unity and ranges from 0.71 to 0.75. Furthermore, the Cobb-Douglas hypothesis, i.e., $\sigma = 1$, can be rejected at any conventional significance level. The parameters γ_l and γ_k are in line with the estimates of equations for the (relative) factor share. In particular, the growth rate of labor-augmenting is positive and varies from 0.026 to 0.028. As it can be expected based on earlier results, unobserved capital-augmenting efficiency shows a downward trend. Overall, these estimates imply that the net growth rate of labor-biased is around 0.055 and, more importantly, the null about Hicks-neutral progress can be reject at any reasonable significance level.

The bottom panel of the table 3 presents residuals diagnostics. Since both factor shares and output have a unit root in our sample the residuals from the analyzed system should be stationary. Here, the results of panel unit root tests are supportive only for the specifications assuming heterogeneous growth rates in factor augmentation. It can be also observed that the cross-sectional dependence observed in data (see table 1) is substantially reduced but it is still significant.

The substantial persistence in the factor shares can be potentially a good candidate explanation for the negative estimates of capital-augmenting technical progress. The decline (rise) in the labor (capital) share has been pronounced and, under gross comple-

Table 3: Estimation of Normalized Supply-Side Systems – constant growth rate of factor augmentation

	Homogeneous γ		Heterogeneous γ_i	
equations:	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)
σ	0.714***	0.755***	0.727***	0.713***
	(0.032)	(0.003)	(0.049)	(0.004)
ξ	1.002***	0.998***	1.003***	1.002***
	(0.002)	(0.002)	(0.001)	(0.001)
γ_l	0.026***	0.028***	0.026***	0.026***
	(0.001)	(0.001)	(0.002)	(0.000)
γ_k	−0.031***	−0.034***	−0.033***	−0.032***
	(0.003)	(0.001)	(0.005)	(0.001)
$\mathcal{LL}$	816.217	2137.6	1104.78	2468.79
$\mathcal{H}_0 : \sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = \gamma_{k,i}$			[0.000]	[0.000]
$\mathcal{H}_0 : \gamma = \gamma_i$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{k,i} = 0$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = 0$	[0.000]	[0.000]	[0.000]	[0.000]
Residuals diagnostics				
equation (9) or (7)				
avg ρ	0.095	0.101	0.153	0.156
avg $\lvert\rho\rvert$	0.322	0.336	0.322	0.299
$\mathcal{CD}$	4.012	4.243	6.471	6.606
IPS	[0.202]	[0.088]	[0.002]	[0.002]
CIPS	[0.576]	[0.635]	[0.212]	[0.123]
equation (8)				
avg ρ		0.077		0.146
avg $\lvert\rho\rvert$		0.357		0.337
$\mathcal{CD}$		3.258		6.184
IPS		[0.357]		[0.003]
CIPS		[0.880]		[0.012]
equation (6)				
avg ρ	0.023	0.033	0.147	0.138
avg $\lvert\rho\rvert$	0.558	0.584	0.341	0.333
$\mathcal{CD}$	0.98	1.376	6.221	5.83
IPS	[0.997]	[0.998]	[0.000]	[0.000]
CIPS	[1.000]	[1.000]	[0.070]	[0.060]

Note: the superscripts ***, ** and * denote the rejection of null about parameters' insignificance at 1%, 5% and 10% significance level, respectively. The expressions in round and squared brackets stand for standard errors and probability values corresponding to respective hypothesis, respectively. The $\mathcal{LL}$ stands for the log likelihood for a given model.

mentarity, the identified growth rate of labor augmentation is not able to account for this trend. Therefore, the empirical pattern in the factor shares is additionally explained by the drop in capital-augmenting efficiency which is consistent with production function due to cross-equation constraints in the joint system estimation.

5 Robustness checks

We now proceed to check whether our baseline results are robust. Our research interest focuses on (i) time-varying technical change, (ii) non-zero mark-up level and, (iii) alternative datasets.

5.1 Time-varying technical change

In the benchmark specification, it is assumed that the growth rates of factor-augmenting technical change are constant over time. However, this textbook assumption seems to be very restrictive since many researchers have documented structural breaks in labor productivity or TFP. Therefore, we consider four additional specifications for factor-augmenting technical change that allow for time dependence.

Firstly, an abrupt break in growth rate of factor augmentation is introduced:

$$\Gamma_{it}^{j} = \exp\left(\left(\gamma_{ij} + \mathcal{DB}_j \gamma_{ij\mathcal{B}_j}\right)(t - t_0)\right), \tag{11}$$

where is $\mathcal{DB}_j$ the dummy variable indicating a sharp change in the growth rate of factor-augmenting technical progress, i.e., $\mathcal{DB}_j = \mathcal{I}(t > \mathcal{B}_j)$, and the parameter $\gamma_{ij\mathcal{B}_j}$ captures this shift. To identify a single structural break a standard 15% sample trimming is employed and breakpoint is selected with the likelihood criterion.

Secondly, we follow the strategy proposed by Klump et al. (2007) and use flexible functional form for Γ_{it}^{j} based on the Box–Cox transformation:

$$\Gamma_{it}^{j} = \exp\left(\frac{t_0 \gamma_{ij}}{\lambda_j}\left(\left(\frac{t}{t_0}\right)^{\lambda_j} - 1\right)\right), \tag{12}$$

where the curvature parameters λ_j describes the shape of the shape of technical progress. The above expression nests: (i) a linear specification ($\lambda_j = 1$), (ii) a hyperbolic trajectory ($\lambda_j < 0$), and (iii) a log-linear specification ($\lambda_j = 0$).

Thirdly, time dummies are agnostically included:

$$\Gamma_{it}^{j} = \exp\left(\gamma_{ij}(t - t_0) + d_{jt}\mathcal{D}_t\right), \tag{13}$$

where is $\mathcal{D}_t$ the dummy variable indicating given year $\mathcal{D}_t = \mathcal{I}(t = \mathcal{D}_t)$ while the parameter d_{jt} captures the potential influence of a common trend in unobserved factor-augmenting technical change.[6]

Fourthly, an unknown deterministic component and number of structural breaks in factor-augmenting technical change can be captured by a trigonometric approximation[7]:

$$\Gamma_{it}^{j} = \exp\left(\gamma_{ij}(t - t_0) + \kappa_{j,sin}\sin\left(\frac{2\pi k_j t}{T}\right) + \kappa_{j,cos}\cos\left(\frac{2\pi k_j t}{T}\right)\right), \tag{14}$$

[6] It should be mentioned that due to the collinearity problem, one dummy variable is omitted. The choice is the indicator variable representing the middle of sample. This strategy seems to be coherent with the normalization.

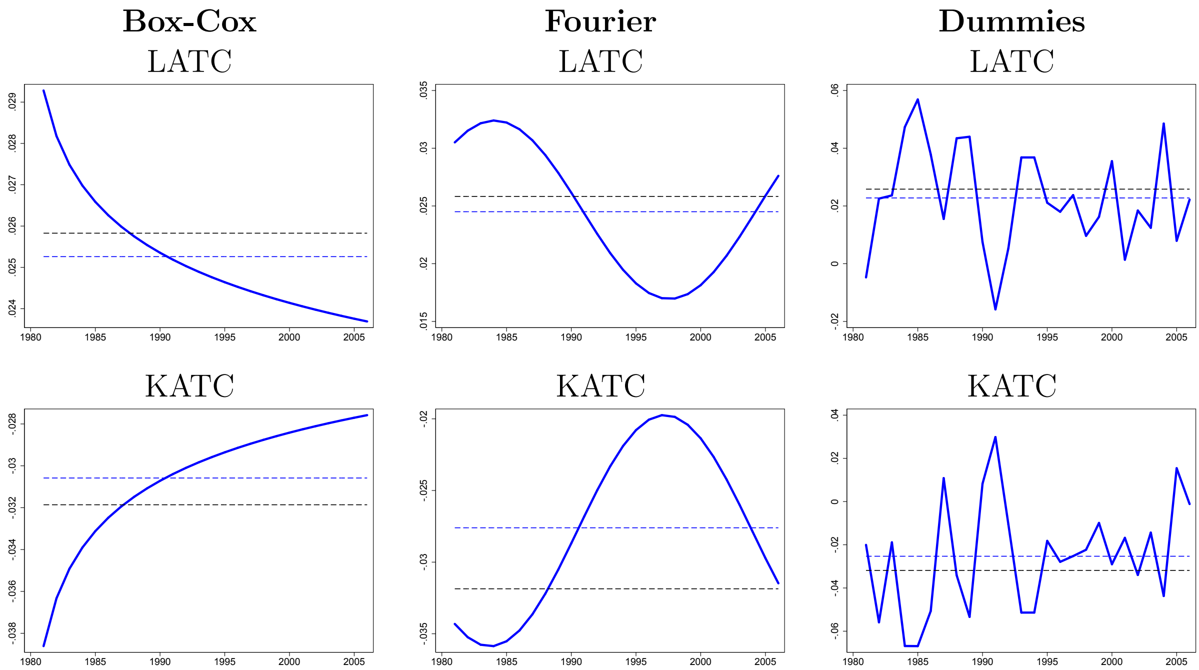
[7] This specification is related to a class of unit root tests basing on the flexible Fourier representation (Becker et al., 2006; Christopoulos and Leon-Ledesma, 2010).

where T is the time dimension, π equals 3.1415, k_j denotes a single frequency of a Fourier expansion and $k_j \in \{1, 2, \ldots, G\}$. We use single integer frequency because it is appealing strategy in empirical application (Ludlow and Enders, 2000). The parameter k_j is restricted to range from 1 to 2 because its higher values would identify some high-frequency noise in our sample ($T = 27$). Finally, we choose k_j that maximizes the likelihood function.

Table 4 summarizes our estimation results that assumes time-varying growth rates of factor augmentation. It is easy to notice that the below unitary substitution is reported for all specifications. Our estimated elasticity of substitution ranges from 0.52 to 0.72. Moreover, net labor-biased technical change is observed. As in the baseline results, the estimated growth rate of labor augmentation is significantly positive while the average growth rate of capital-augmenting technical change is strongly negative.

Let us now concentrate on the variation of factor augmentation. Except for the Box-Cox specification, the null about time invariant growth rates of factor-augmenting technical change can be rejected at any reasonable significance level. The abrupt break in both labor- and capital-augmenting technical change can detected in the middle of 1980s. The opposite signs of estimated parameters capturing breaks suggest that the absolute factor augmentation has been slower since the second half of the 1980s. An analogous story can be revealed by the Box-Cox case. Namely, the below unitary estimated Box-Cox curvature parameters, i.e., λ_j and λ_k, imply decrease in factor-augmenting technical change. However, the null about exponential pattern, i.e., $\lambda_l = \lambda_k = 1$, is not rejected in all cases.

Figure 2: Implied Path of the Growth Rates of Factor-Augmenting Technical Change



Note: the blue dashed lines refer to the average growth rate of factor-augmenting technical in the considered specification while the black dashed lines represent the baseline estimates. The above lines are backed out from the estimates of three-equation system with heterogeneous growth rates of factor augmentation.

Figure 2 illustrates the implied time path for the factor-augmentation. Our previous observation about slowdown (in absolute terms) in factor augmentation is confirmed by

Table 4: Estimation of Normalized Supply-Side System – Summary of the Estimates based on time-varying factor augmentation

	Homogeneous γ		Heterogeneous γ_i	
equations:	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)
an abrupt break in factor augmentation				
σ	0.696***	0.712***	0.687***	0.712***
γ_l	0.029***	0.032***	0.029***	0.03***
γ_k	−0.036***	−0.041***	−0.035***	−0.038***
$\gamma_{l,\mathcal{B}}$	−0.006***	−0.009***	−0.006***	−0.006***
$\mathcal{B}_l$	1984	1985	1985	1985
$\gamma_{k,\mathcal{B}}$	0.009***	0.015***	0.007***	0.009***
$\mathcal{B}_k$	1984	1985	1985	1985
$\mathcal{LL}$	825.893	2173.969	1197.679	2595.101
$\sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]
$\gamma_{l,\mathcal{B}} = \gamma_{k,\mathcal{B}} = 0$	[0.000]	[0.000]	[0.000]	[0.000]
Box-Cox case				
σ	0.698***	0.709***	0.703***	0.689***
γ_l	0.024***	0.025***	0.025***	0.025***
γ_k	−0.029***	−0.03***	−0.031***	−0.03***
λ_l	0.769***	0.726***	0.971***	0.927***
λ_k	0.762***	0.623***	1.012***	0.884***
$\mathcal{LL}$	822.594	2160.575	1105.327	2472.561
$\mathcal{H}_0 : \sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{li} = \gamma_{ki}$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \lambda_l = \lambda_k = 1$	[0.002]	[0.000]	[0.576]	[0.023]
$\mathcal{H}_0 : \lambda_k = 1$	[0.000]	[0.000]	[0.503]	[0.165]
$\mathcal{H}_0 : \lambda_k = 1$	[0.004]	[0.000]	[0.831]	[0.060]
Year dummies				
σ	0.69***	0.73***	0.569***	0.601***
γ_l	0.053***	0.048***	0.04***	0.037***
γ_k	−0.086***	−0.061**	−0.057***	−0.051***
$\mathcal{LL}$	843.862	2202.467	1163.418	2551.53
$\mathcal{H}_0 : \sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = \gamma_{k,i}$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \mathcal{D}_{tl} = \mathcal{D}_{tk} = 0$	[0.000]	[0.000]	[0.000]	[0.000]
a trigonometric approximation				
σ	0.707***	0.733***	0.622***	0.627***
k^L	2	1	1	1
k^K	2	1	2	1
$\mathcal{LL}$	826.794	2165.363	1127.776	2493.127
$\mathcal{H}_0 : \sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l.i} = \gamma_{k.i}$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \kappa_i = 0$	[0.000]	[0.000]	[0.000]	[0.000]

Note: as in table 3. The numbers in the above table summarizes table A.2–A.4.

other specifications. Even if the year dummies are included to capture some short-run variation, the implied growth rates of labor- and capital-augmenting progress are in modulus higher in the beginning of the sample. The same applies to the paths predicted by three-equations system using a trigonometric representation because the selected frequencies of a Fourier expansion, i.e., k^L, $k^K = 1$, equals unity.

In all time-varying cases, both the goodness-of-fit and statistical properties are more appealing than in the respective baseline systems. The null about time independence of factor augmentation is rejected in most of the considered specifications. Moreover, the results of panel unit root tests are slightly more satisfactory and the null is relatively easier to reject.

There are at least two arguments supporting the implied paths of factor-augmenting technical change as well as the detected breakpoints. Firstly, the detected breakpoints corroborate with behavior of the (relative) factor shares. Namely, as it is depicted on figure 1, the most pronounced rise in the capital share or relative income share can be observed in the beginning of our sample. Secondly, the implied path of factor-augmenting technical change is also coherent with empirical studies documenting a marked deceleration in labor productivity growth in the Eurozone countries since the beginning of the 1980s (Benati, 2007).[8]

5.2 Non-zero markups

In the KLEMS database the capital share is measured implicitly and it is calculated as unity reduced by the labor share. Under perfect competition this is valid choice. But in the presence of imperfect competition an aggregate markups are ascribed to the capital share. Such mismeasurement might deteriorate identification of deep production characteristics. For that reason, we agnostically re-calculate the capital share assuming that it contains monopolistic markups.

Table A.5 summarizes the estimation results for the extreme case assuming that the aggregate markup is constant over time and equals 10%, i.e., $\mu = 0.1$ in (8) and (9). Although we artificially boost persistence of relative factor shares our results are qualitatively the same. The estimated elasticity of substitution is slightly lower in comparison to the baseline estimates and ranges from 0.61 to 0.58. Moreover, the strong upward trend in net labor-augmenting technical change is still to observed.

Figure 3: Dependence of estimates on aggregate markups (μ) in the three-equation system estimation

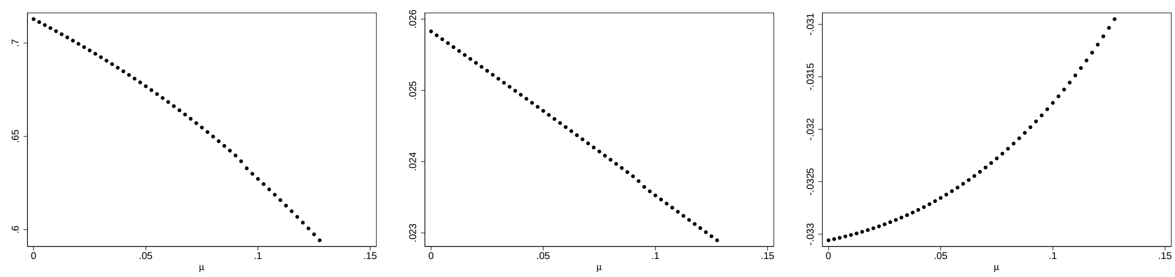


Figure 3 illustrates how the markups would affect our estimation results. There is an intuitive trade-off. With the higher level of markup, the rise in the (re-calculated) capital

[8]Note that the EA countries make up more than half of the sample. In Appendix C the estimation results, including country-specific detected breakpoints, are presented at the country level.

share would be stronger and, as a results, lower σ is required to account for the decline in the labor share. Since we use cross-equations restriction in our estimation strategy the accompanying fall in the growth rates of factor augmentation is negligible.

5.3 Alternative datasets

To strengthen our empirical evidence we use two alternative datasets to estimate the normalized supply-side system: (i) the WIOD database, and (ii) the TED database. The detailed description of data used in this exercise is delegated to Appendix B. These datasets cover a large sample of both developed and developing countries. Therefore, to check robustness we estimate the panel normalized supply-side system for our baseline set of countries as well as sample extended by other developed economies. Our choice is discussed in Appendix B.

Despite the larger cross-country dimension the alternative dataset have one shortcoming, though. Both databases offer series starting in 1995. As a result, shorter time span might be crucial for identification of deep technological parameters. Apart from the baseline setting we estimate normalized supply-side system assuming non-zero markups. This choice stems out from the fact that there are systematic differences in each country's factor shares between databases in the overlapping time period.[9] Thus, the case with $\mu = 0.1$ is also considered.

Table 5 presents the estimation results for the alternative datasets. Let us start with the results basing on the WIOD database. For the baseline set of countries, the estimated parameters of the normalized supply-side system are very close to the characteristics documented in section 4. The estimated elasticity of substitution varies from 0.61 and to 0.82. In addition, it is straightforward to observed that the average growth rate of labor augmentation is positive while capital-augmenting efficiency fall in our sample. The lower growth rates of factor augmentation are consistent with the previous evidence in favor of occurrence of a structural break in factor-augmenting technical progress or, more generally, time-varying technical progress.

If we extend the WIOD database by additional developed economies our main findings also remain robust. The estimated elasticity of substitution becomes higher but it is still below unity. The same applies to the TED database which offers substantially higher estimates of σ but in all specifications gross complementarity of capital and labor can be found.

To rationalize the numbers in table 5 let us move to the statistical properties of the considered estimation results (see Appendix B). It turns out that the specifications that predict relatively high σ are rather problematic due to the weak evidence of the residuals' mean reversion. If we accept only the models that have stationary residuals at 10% significance level the estimated elasticity of substitution varies from 0.76 to 0.85.

Nevertheless, the below unitary elasticity is confirmed by the evidence basing on the alternative datasets. This fact, together with our estimation results that allow for time-varying factor augmentation and experiment with non-zero markups, imply that the gross

[9]It can be found that for all countries the labor share is substantially higher in the KLEMS database between 1995-2006. In comparison with the WIOD database the average difference is about 3.3 percentage points while the TED database offers the labor share that is lower than the baseline series by 7.8 percentage points.

Table 5: Estimation of Normalized Supply-Side System – Summary of the Estimates Based on Alternative Datasets

TC:	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
EQ:	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)
WIOD – baseline set of countries								
	$\mu = 0$				$\mu = 0.1$			
σ	0.67***	0.749***	0.795***	0.827***	0.609***	0.71***	0.719***	0.765***
γ_l	0.02***	0.024***	0.026***	0.028***	0.019***	0.022***	0.022***	0.024***
γ_k	−0.011***	−0.016***	−0.02**	−0.024***	−0.011***	−0.017***	−0.019***	−0.023***
WIOD – extended set of countries								
	$\mu = 0$				$\mu = 0.1$			
σ	0.872***	0.862***	0.935***	0.853***	0.817***	0.828***	0.774***	0.759***
γ_l	0.036***	0.036***	0.064***	0.035***	0.031***	0.03***	0.029***	0.028***
γ_k	−0.034***	−0.035***	−0.083***	−0.037***	−0.033***	−0.032***	−0.032***	−0.03***
TED – baseline set of countries								
	$\mu = 0$				$\mu = 0.1$			
σ	0.923***	0.962***	0.878***	0.882***	0.898***	0.95***	0.829***	0.846***
γ_l	0.025***	0.02***	0.017***	0.017***	0.02***	0.016***	0.015***	0.015***
γ_k	−0.018**	−0.01*	−0.007	−0.006***	−0.017**	−0.01*	−0.005	−0.006***
TED – extended set of countries								
	$\mu = 0$				$\mu = 0.1$			
σ	0.881***	0.89***	0.985***	0.894***	0.86***	0.872***	0.979***	0.862***
γ_l	0.02***	0.021***	0.038***	0.027***	0.018***	0.018***	0.031***	0.023***
γ_k	−0.001	−0.003	−0.025***	−0.011***	−0.002	−0.003	−0.023***	−0.011***

Note: the numbers in the above table summarizes tables in Appendix B. The second row (EQ) lists the equations in system estimation. The first row (TC) contains information about factor-augmenting technical change, i.e. (i) captures homogeneous growth rates while (ii) refers to heterogeneous ones.

complementarity between labor and capital in developed countries is appealingly robust.

6 Estimates at the country level

In this section we provide systematic estimates of the elasticity of substitution between labor and capital at the country level. The detailed description of our strategy is delegated to Appendix C.

Table 6 summarizes the estimated σ while the detailed investigation is delegated to appendix C. The first impression is that the single-approach leads to the inconsistency of the estimates which is discussed in the section 4. On the one hand, the equation for labor share predicts that capital and labor are gross substitutes for nine out of twelve countries. On the other hand, the estimates based on the first-order condition for capital (9) imply below unitary elasticity of substitution for all economies except for Belgium. Importantly, the equation (9) also predicts the negative growth pattern of capital-augmenting technological change for all countries except for the Netherlands. Once again, the above inconsistency can be resolved by the estimates of the equation for the relative factor shares

(7). For nine out of twelve countries, these results indicate gross complementarity between labor and capital together with strong net labor-augmenting technical change.

Apart from the economic ambiguity of the single-equation approach results this strategy very in precise estimates of deep technological parameters. Relatively large standard errors do not allow us to test conventional hypotheses. According to numbers in table 6 the the Cobb-Douglas null is rejected at 5% for more than half of considered specifications. This feature is contradictory to the historical trajectory of the factor shares in our sample (see figure 1). The explanation for these results might be associated with a fact that in small sample size, i.e., $T = 27$, any single-equation based approach is not able to identify deep technological parameters.

Due to cross-equation restrictions in underlying parameters the above shortcomings are overcome with the estimation of three-equation supply side system. For the most of countries the estimated value of σ is below unity. Only for Belgium gross substitutability between labor and capital is reported in specification assuming constant growth rates of factor augmentation. However, this outlying estimate ($\sigma > 4$) disappears when some time-varying technical change is introduced. As it is broadly documented in Appendix C, production has been fueled by labor-augmenting technical change ($\gamma_l > 0$). Meanwhile, like in panel estimation, the pronounced rise in the capital share (relative factor shares) has been amplified by downward trend in capital-augmenting efficiency ($\gamma_k < 0$).

Let us now concentrate on cross-country heterogeneity in the value of elasticity of substitution. We can distinguish two group of countries. The first group refers to the economies for which consistent estimates of σ are predicted by various specifications. Clearly, for Austria, Germany and the United States the estimated elasticity of substitution does not exceed unity and equals on average 0.83, 0.49 and 0.55.

In the second group, the identification of deep technological parameters is quite difficult since there is an appealing evidence in favor time dependence of factor augmentation. It is strongly illustrated by incredible estimated growth rates of the factor augmentation ($\gamma_j > 0.1$) or non-stationarity of the residuals from the baseline three-equation system.

Let us discuss some extreme examples. For Japan, the benchmark specification produces the σ around 0.95 and non-stationary residuals. The latter problem can be overcome by introducing any form of time dependence in technical progress. As a result, the estimated σ is reduced to around 0.5 and factor-augmenting technical change decelerates (in the Box-Cox case λ_l is around 0.4 while λ_k is below 0.7). The lowest (reasonable) estimates of elasticity of substitution can be reported for France. In this case, the residuals from the baseline specification have unit root. Once again, this problem is resolved when some time variation in factor augmentation is introduced. Then, the estimated σ ranges from 0.22 to 0.465. In the case of Spain, the residuals mean reversion can be found only for the supply-side system assuming Fourier approximation of smooth breaks. Finally, the estimated baseline supply-side system for Belgium implies that labor and capital are gross substitutes. However, the ADF statistics for residuals are extremely high and this facts questions the above unitary σ. The extended systems yield the estimates of σ below unity as well as stationary residuals.

Nevertheless, the bottom panel of table 6 contains descriptive statistics of estimates for each considered specification. Clearly, it is worth to notice that the median estimates of σ converges to the panel estimation results and ranges from 0.58 to 0.89 in the system estimation. In order to make our (average) results more economically interpretable we use data GDP as weights. It turns out that the GDP-weighted average σ is lower than unweighted average. This discrepancy suggests that larger economies are characterized by lower elasticity of substitution.[10]

Summing up, the above investigation at the country level confirms the fact that the elasticity of substitution between labor and capital is below unity.

7 Concluding remarks

In this paper we study the aggregate elasticity of substitution between labor and capital in advanced economies. Our comprehensive evidence suggest that labor and capital are gross complementary and σ equals on average 0.7. In addition, factor-augmenting technical progress shows an interesting pattern. While the growth rate of labor-biased technical change are positive the capital-augmenting efficiency exhibits downward trend. Importantly, these production characteristics are confirmed by empirical evidence at the country level. Clearly, these features are also corroborated by our robustness checks.

Our results have strong implication for a lively debate on rising income inequality and, in particular, understanding broadly documented trends in the factor shares. Under gross complementarity between labor and capital, capital deepening cannot explain the strong downward tendency of the labor share in developed countries since 1970s. Specifically, our estimates imply that net labor-augmenting technical progress has been major driver of the recent trends in the factor shares.

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[10] In fact, the average σ for four the most important economies the average σ obtained in the system estimation does not exceed 0.5 while the corresponding average for remaining countries (except for outlying Belgium) equals 0.8.

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Table 6: Summary of the country estimates

equation:	Single-equation approach (8)	(9)	(7)	Three-equation system (10)	(11)	(12)	(14)
			AUT				
σ	0.905***	0.859***	0.816***	0.819***	0.962***	0.845***	0.602***
$\mathcal{H}_0 : \sigma = 1$	[0.489]	[0.490]	[0.387]	[0.000]	[0.000]	[0.000]	[0.000]
			BEL				
σ	6.623	1.233	4.103	4.678***	0.422***	0.949***	0.894***
$\mathcal{H}_0 : \sigma = 1$	[0.375]	[0.784]	[0.762]	[0.000]	[0.000]	[0.000]	[0.000]
			DNK				
σ	1.706***	0.405***	1.477	0.942***	0.357***	0.432***	0.699***
$\mathcal{H}_0 : \sigma = 1$	[0.063]	[0.000]	[0.618]	[0.000]	[0.000]	[0.000]	[0.000]
			FIN				
σ	2.898*	0.563***	0.495***	0.705***	0.852***	0.847***	0.69***
$\mathcal{H}_0 : \sigma = 1$	[0.219]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
			FRA				
σ	5.905	0.319**	0.371*	0.671***	0.217***	0.26***	0.465***
$\mathcal{H}_0 : \sigma = 1$	[0.514]	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
			DEU				
σ	0.834***	0.489***	0.400***	0.396***	0.389***	0.399***	0.525***
$\mathcal{H}_0 : \sigma = 1$	[0.201]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
			ITA				
σ	1.539***	0.360***	0.466***	0.886***	0.971***	0.801***	0.756***
$\mathcal{H}_0 : \sigma = 1$	[0.053]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
			JPN				
σ	1.386***	0.453***	1.201**	0.949***	0.455***	0.507***	0.567***
$\mathcal{H}_0 : \sigma = 1$	[0.013]	[0.000]	[0.678]	[0.000]	[0.000]	[0.000]	[0.000]
			NLD				
σ	3.307	1.775	0.81***	0.899***	0.65***	0.902***	0.745***
$\mathcal{H}_0 : \sigma = 1$	[0.471]	[0.491]	[0.195]	[0.000]	[0.000]	[0.000]	[0.000]
			ESP				
σ	1.276***	0.423***	0.958***	0.979***	0.998***	0.958***	0.722***
$\mathcal{H}_0 : \sigma = 1$	[0.135]	[0.000]	[0.921]	[0.000]	[0.016]	[0.000]	[0.000]
			USA				
σ	0.878***	0.538***	0.453***	0.485***	0.512***	0.506***	0.461***
$\mathcal{H}_0 : \sigma = 1$	[0.362]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
			GBR				
σ	0.999***	0.58***	0.804*	0.982***	0.744***	0.718***	0.943***
$\mathcal{H}_0 : \sigma = 1$	[0.024]	[0.005]	[0.641]	[0.030]	[0.000]	[0.000]	[0.000]
$\bar{\sigma}$	2.355	0.666	1.030	1.116	0.628	0.677	0.672
median σ	1.462	0.513	0.807	0.893	0.581	0.760	0.695
$\bar{\sigma}^{GDP}$	1.536	0.525	0.687	0.718	0.532	0.541	0.562

Note: in the bottom panel the $\bar{\sigma}$ and $\bar{\sigma}^{GDP}$ denotes the simple (unweighted) average and the GDP-weighted average of the estimated elasticity of substitution between labor and capital. The data on GDP in current USD are taken from WDI. An adjustment by purchasing parity does not change significantly the presented numbers. In three-equation systems, the *equation* in the second row refers to the assumption on the form of factor-augmenting technical change.

A Additional tables

Table A.1: Estimation of Normalized Supply-Side – time-varying growth fate of technical progress – single break in factor-augmenting technical change

	Homogeneous γ		Heterogeneous γ_i	
σ	0.696***	0.712***	0.687***	0.712***
	(0.031)	(0.002)	(0.053)	(0.004)
ξ	1.003***	0.998***	1.005***	1.005***
	(0.003)	(0.003)	(0.001)	(0.001)
γ_l	0.029***	0.032***	0.029***	0.03***
	(0.002)	(0.001)	(0.002)	(0.001)
γ_k	−0.036***	−0.041***	−0.035***	−0.038***
	(0.004)	(0.002)	(0.005)	(0.001)
$\gamma_{l,\mathcal{B}_l}$	−0.006***	−0.009***	−0.006***	−0.006***
	(0.002)	(0.001)	(0.001)	(0.001)
$\mathcal{B}_l$	1984	1985	1985	1985
$\gamma_{k,\mathcal{B}_k}$	0.009***	0.015***	0.007***	0.009***
	(0.003)	(0.002)	(0.003)	(0.002)
$\mathcal{B}_k$	1984	1985	1985	1985
$\mathcal{LL}$	825.893	2173.969	1197.679	2595.101
$\mathcal{H}_0 : \sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma = \gamma_i$			[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l,\mathcal{B}_l} = \gamma_{k,\mathcal{B}_k} = 0$	[0.000]	[0.000]	[0.000]	[0.000]
Residuals diagnostics				
equation (9) or (7)				
avg ρ	−0.001	0.024	0.092	0.106
avg $\lvert\rho\rvert$	0.325	0.326	0.284	0.293
$\mathcal{CD}$	−0.049	1.009	3.877	4.494
IPS	[0.210]	[0.133]	[0.000]	[0.000]
CIPS	[0.932]	[0.951]	[0.052]	[0.039]
equation (8)				
avg ρ		−0.007		0.076
avg $\lvert\rho\rvert$		0.322		0.261
$\mathcal{CD}$		−0.289		3.220
IPS		[0.377]		[0.000]
CIPS		[0.973]		[0.037]
equation (6)				
avg ρ	−0.014	−0.014	0.116	0.115
avg $\lvert\rho\rvert$	0.574	0.596	0.287	0.286
$\mathcal{CD}$	−0.599	−0.595	4.908	4.857
IPS	[0.998]	[0.998]	[0.000]	[0.000]
CIPS	[1.000]	[0.998]	[0.002]	[0.003]

Note: as in table 3.

Table A.2: Estimation of Normalized Supply-Side – time varying technical progress – Box-Cox specification

	Homogeneous γ		Heterogeneous γ_i	
σ	0.698***	0.709***	0.703***	0.689***
	(0.032)	(0.002)	(0.052)	(0.007)
ξ	1.005***	0.998***	1.004***	1.002***
	(0.003)	(0.003)	(0.002)	(0.002)
γ_l	0.024***	0.025***	0.025***	0.025***
	(0.001)	(0.001)	(0.002)	(0.000)
γ_k	−0.029***	−0.030***	−0.031***	−0.03***
	(0.002)	(0.001)	(0.004)	(0.001)
λ_l	0.769***	0.726***	0.971***	0.927***
	(0.062)	(0.045)	(0.043)	(0.053)
λ_k	0.762***	0.623***	1.012***	0.884***
	(0.083)	(0.054)	(0.055)	(0.062)
$\mathcal{LL}$	822.594	2160.575	1105.327	2472.561
$\mathcal{H}_0 : \sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = \gamma_{k,i}$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma = \gamma_i$			[0.000]	[0.000]
$\mathcal{H}_0 : \lambda_l = \lambda_k = 1$	[0.002]	[0.000]	[0.576]	[0.023]
$\mathcal{H}_0 : \lambda_k = 1$	[0.000]	[0.000]	[0.503]	[0.165]
$\mathcal{H}_0 : \lambda_k = 1$	[0.004]	[0.000]	[0.831]	[0.060]
Residuals diagnostics				
equation (9) or (7)				
avg ρ	0.032	0.025	0.154	0.129
avg $\|\rho\|$	0.322	0.339	0.322	0.285
$\mathcal{CD}$	1.337	1.051	6.480	5.454
IPS	[0.209]	[0.134]	[0.002]	[0.000]
CIPS	[0.703]	[0.703]	[0.193]	[0.086]
equation (8)				
avg ρ		0.002		0.114
avg $\|\rho\|$		0.334		0.317
$\mathcal{CD}$		0.085		4.827
IPS		[0.449]		[0.002]
CIPS		[0.984]		[0.013]
equation (6)				
avg ρ	−0.013	0.001	0.129	0.124
avg $\|\rho\|$	0.573	0.588	0.325	0.336
$\mathcal{CD}$	−0.543	0.034	5.441	5.237
IPS	[0.989]	[0.988]	[0.000]	[0.000]
CIPS	[1.000]	[1.000]	[0.028]	[0.027]

Note: as in table 3.

Table A.3: Estimation of Normalized Supply-Side – time varying technical progress – dummy variables

	No γ		Homogeneous γ		Heterogeneous γ_i	
σ	0.692***	0.731***	0.690***	0.730***	0.569***	0.601***
	(0.030)	(0.002)	(0.030)	(0.002)	(0.038)	(0.003)
ξ	1.004***	1.004***	1.01***	1.006***	1.008***	1.008***
	(0.013)	(0.012)	(0.007)	(0.007)	(0.003)	(0.003)
γ_l			0.053***	0.048***	0.04***	0.037***
			(0.019)	(0.017)	(0.010)	(0.009)
γ_k			−0.086***	−0.061**	−0.057***	−0.051***
			(0.031)	(0.025)	(0.015)	(0.012)
$\mathcal{LL}$	844.490	2203.265	843.863	2202.467	1163.418	2551.530
$\mathcal{H}_0 : \sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{li} = \gamma_{ki}$			[0.003]	[0.004]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma = \gamma_i$					[0.000]	[0.000]
$\mathcal{H}_0 : \mathcal{D}_{tl} = \mathcal{D}_{tk} = 0$			[0.219]	[0.000]	[0.000]	[0.000]
Residuals diagnostics						
equation (9) or (7)						
avg ρ	−0.065	−0.021	−0.066	−0.018	−0.061	−0.011
avg $\lvert\rho\rvert$	0.347	0.320	0.349	0.317	0.307	0.291
$\mathcal{CD}$	−2.761	−0.901	−2.800	−0.769	−2.555	−0.481
IPS	[0.213]	[0.122]	[0.214]	[0.122]	[0.002]	[0.000]
CIPS	[0.619]	[0.216]	[0.873]	[0.270]	[0.106]	[0.023]
equation (8)						
avg ρ		−0.002		0.000		−0.001
avg $\lvert\rho\rvert$		0.335		0.000		0.284
$\mathcal{CD}$		−0.066		0.000		−0.029
IPS		[0.367]		[0.000]		[0.001]
CIPS		[0.851]		[0.000]		[0.009]
equation (6)						
avg ρ	−0.067	−0.021	−0.064	−0.020	−0.064	−0.020
avg $\lvert\rho\rvert$	0.591	0.576	0.589	0.575	0.340	0.331
$\mathcal{CD}$	−2.816	−0.880	−2.694	−0.851	−2.722	−0.856
IPS	[0.992]	[0.992]	[0.993]	[0.992]	[0.000]	[0.000]
CIPS	[0.916]	[0.994]	[0.979]	[0.997]	[0.056]	[0.046]

Note: as in table 3.

Table A.4: Estimation of Normalized Supply-Side – time varying technical progress – Fourier

	Homogeneous γ		Heterogeneous γ_i	
σ	0.707***	0.733***	0.622***	0.627***
	(0.031)	(0.002)	(0.046)	(0.003)
ξ	1.002***	0.998***	1.002***	1.002***
	(0.000)	(0.000)	(0.000)	(0.000)
γ_l	0.025***	0.029***	0.023***	0.025***
	(0.001)	(0.001)	(0.001)	(0.000)
γ_k	−0.031***	−0.038***	−0.026***	−0.028***
	(0.003)	(0.001)	(0.002)	(0.001)
κ_L^{SIN}	−0.003	0.035***	0.001	0.016***
	(0.008)	(0.010)	(0.005)	(0.005)
κ_L^{COS}	−0.024***	−0.046***	−0.013***	−0.029***
	(0.009)	(0.006)	(0.003)	(0.004)
κ_K^{SIN}	−0.004	−0.069***	−0.007	−0.019**
	(0.014)	(0.015)	(0.005)	(0.008)
κ_K^{COS}	0.058***	0.064***	0.021***	0.029***
	(0.015)	(0.010)	(0.004)	(0.006)
k^L	2	1	1	1
k^K	2	1	2	1
$\mathcal{LL}$	826.794	2165.363	1127.776	2493.127
$\mathcal{H}_0 : \sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = \gamma_{k,i}$	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma = \gamma_i$			[0.000]	[0.000]
$\mathcal{H}_0 : \kappa_i = 0$	[0.000]	[0.000]	[0.000]	[0.000]
Residuals diagnostics				
equation (9) or (7)				
avg ρ	0.043	0.057	0.098	0.133
avg $\lvert\rho\rvert$	0.338	0.317	0.324	0.267
$\mathcal{CD}$	1.795	2.391	4.122	5.618
IPS	[0.205]	[0.120]	[0.002]	[0.000]
CIPS	[0.702]	[0.447]	[0.080]	[0.018]
equation (8)				
avg ρ		0.012		0.043
avg $\lvert\rho\rvert$		0.312		0.251
$\mathcal{CD}$		0.523		1.820
IPS		[0.366]		[0.001]
CIPS		[0.955]		[0.006]
equation (6)				
avg ρ	0.017	−0.019	0.086	0.028
avg $\lvert\rho\rvert$	0.565	0.588	0.304	0.323
$\mathcal{CD}$	0.723	−0.810	3.637	1.174
IPS	[0.003]	[0.003]	[0.001]	[0.000]
CIPS	[0.999]	[1.000]	[0.016]	[0.014]

Note: a as in table 3.

Table A.5: Estimation of Normalized Supply-Side – time invariant technical progress – non-zero markup ($\mu = 0.1$)

	Homogeneous γ		Heterogeneous γ_i	
σ	0.611***	0.684***	0.612***	0.627***
	(0.035)	(0.003)	(0.053)	(0.005)
ξ	1.003***	0.997***	1.004***	1.003***
	(0.003)	(0.002)	(0.001)	(0.001)
γ_l	0.023***	0.025***	0.023***	0.024***
	(0.001)	(0.001)	(0.001)	(0.000)
γ_k	−0.031***	−0.034***	−0.032***	−0.032***
	(0.003)	(0.001)	(0.004)	(0.001)
$\mathcal{LL}$	696.282	1864.58	985.197	2199.03
$\sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]
$\gamma_{l,i} = \gamma_{k,i}$			[0.000]	[0.000]
$\gamma = \gamma_i$	[0.000]	[0.000]	[0.000]	[0.000]
$\gamma_{k,i} = 0$	[0.000]	[0.000]	[0.000]	[0.000]
$\gamma_{l,i} = 0$	[0.000]	[0.000]	[0.000]	[0.000]
Residuals diagnostics				
equation (9) or (7)				
avg ρ	0.096	0.113	0.17	0.167
avg $\lvert\rho\rvert$	0.344	0.335	0.33	0.302
$\mathcal{CD}$	4.05	4.755	7.171	7.062
IPS	[0.161]	[0.049]	[0.001]	[0.002]
CIPS	[0.506]	[0.342]	[0.097]	[0.169]
equation (8)				
avg ρ		0.082		0.154
avg $\lvert\rho\rvert$		0.341		0.338
$\mathcal{CD}$		3.449		6.521
IPS	[0.000]	[0.458]	[0.000]	[0.002]
CIPS	[0.000]	[0.883]	[0.000]	[0.162]
equation (6)				
avg ρ	0.02	0.025	0.133	0.119
avg $\lvert\rho\rvert$	0.59	0.61	0.36	0.347
$\mathcal{CD}$	0.858	1.036	5.625	5.022
IPS	[0.999]	[0.999]	[0.000]	[0.000]
CIPS	[1.000]	[1.000]	[0.040]	[0.034]

Note: as in table 3.

B Alternative datasets

B.1 WIOD database

The first alternative dataset is the WIOD Socio Economic Accounts. Since its contruction is very similar to the EU KLEMS database we use Gross value added (volume index) to measure real output, total hours worked by persons engaged to proxy labor input. The capital stock is measure with Real fixed capital stock (in 1995 stock prices). Finnally, the labor (capital) share is calculated as a simple relation of labor (capital) compensation to nominal gross value added.

A broader set of countries extend our sample by 9 economies: Australia, Canada, Ireland, Greece, Korea, Luxemburg, Portugal, Sweden, Taiwan.

B.2 TED database

Our second alternative database is TED Growth Accounting and Total Factor Productivity. The output is calculated as the cumulative sum of log changes in GDP. We proxy changes in a labor input as a sum of changes in labor quantity and quality and the sum is cumulated. The labor share corresponds to Share of Total Labor Compensation in GDP while the capital share is calculated explicitly. There is no aggregate measure of capital services and in the TED database since capital services are divided in ICT assets and non-ICT assets. Using data on their log changes and contribution to GDP growth we calculate their remuneration. Next, based on their remuneration we calculate weighted logged changes which are cumulated.

We extend our sample by 12 countries: Australia, Canada, Ireland, Greece, Korea, Luxemburg, New Zealand, Norway, Portugal, Sweden, Switzerland, Taiwan.

Table B.1: Estimation of Normalized Supply-Side – WIOD database – baseline sample

	No mark-up				Mark-up at 10%			
	Homogeneous γ		Heterogeneous γ_i		Homogeneous γ		Heterogeneous γ_i	
equations:	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)
σ	0.67***	0.749***	0.795***	0.827***	0.609***	0.71***	0.719***	0.765***
	(0.051)	(0.002)	(0.070)	(0.005)	(0.054)	(0.002)	(0.083)	(0.006)
ξ	1.000***	1.002***	1.001***	1.001***	1.000***	1.002***	1.001***	1.001***
	(0.051)	(0.002)	(0.070)	(0.005)	(0.054)	(0.002)	(0.083)	(0.006)
γ_l	0.02***	0.024***	0.026***	0.028***	0.019***	0.022***	0.022***	0.024***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
γ_k	−0.011***	−0.016***	−0.02**	−0.024***	−0.011***	−0.017***	−0.019***	−0.023***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\mathcal{LL}$	629.465	1497.66	851.684	1756.61	588.889	1405.09	819.026	1672.49
$\mathcal{H}_0 : \sigma = 1$	[0.000]	[0.000]	[0.004]	[0.000]	[0.000]	[0.000]	[0.001]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = \gamma_{k,i}$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma = \gamma_i$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{k,i} = 0$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = 0$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Residuals diagnostics								
equation (9) or (7)								
avg ρ	−0.036	−0.045	0.027	0.022	−0.036	−0.047	0.026	0.02
avg $\lvert\rho\rvert$	0.423	0.462	0.439	0.442	0.421	0.454	0.442	0.441
$\mathcal{CD}$	−1.063	−1.322	0.779	0.618	−1.083	−1.384	0.77	0.563
IPS	[0.400]	[0.200]	[0.000]	[0.000]	[0.384]	[0.209]	[0.000]	[0.000]
CIPS	[0.981]	[0.921]	[0.095]	[0.026]	[0.981]	[0.945]	[0.075]	[0.024]
equation (8)								
avg ρ		−0.028		0.032		−0.028		0.036
avg $\lvert\rho\rvert$		0.427		0.403		0.434		0.407
$\mathcal{CD}$		−0.824		0.968		−0.828		1.077
IPS		[0.838]		[0.000]		[0.644]		[0.000]
CIPS		[0.999]		[0.046]		[0.999]		[0.044]
equation (6)								
avg ρ	−0.012	−0.018	0.164	0.152	−0.017	−0.026	0.12	0.111
avg $\lvert\rho\rvert$	0.66	0.631	0.375	0.379	0.637	0.616	0.347	0.352
$\mathcal{CD}$	−0.37	−0.546	4.859	4.496	−0.516	−0.772	3.581	3.312
IPS	[0.962]	[0.966]	[0.003]	[0.005]	[0.962]	[0.986]	[0.001]	[0.002]
CIPS	[1.000]	[1.000]	[0.008]	[0.084]	[1.000]	[1.000]	[0.112]	[0.006]

Note: as in table 3.

Table B.2: Estimation of Normalized Supply-Side – WIOD database – extended sample

	No mark-up				Mark-up at 10%			
	Homogeneous γ		Heterogeneous γ_i		Homogeneous γ		Heterogeneous γ_i	
equations:	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)
σ	0.872***	0.862***	0.935***	0.853***	0.817***	0.828***	0.774***	0.759***
	(0.025)	(0.008)	(0.010)	(0.008)	(0.033)	(0.011)	(0.039)	(0.011)
ξ	1.001***	1.002***	1.006**	1.003***	1.001***	1.002***	1.003***	1.002***
	(0.025)	(0.008)	(0.010)	(0.008)	(0.033)	(0.011)	(0.039)	(0.011)
γ_l	0.036***	0.036***	0.064***	0.035***	0.031***	0.03***	0.029***	0.028***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
γ_k	−0.034***	−0.035***	−0.083***	−0.037***	−0.033***	−0.032***	−0.032***	−0.03***
	(0.005)	(0.003)	(0.012)	(0.003)	(0.005)	(0.004)	(0.006)	(0.002)
$\mathcal{LL}$	909.073	1952.06	1232.5	2434.53	819.302	1713.78	1133.12	2190.45
$\mathcal{H}_0 : \sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = \gamma_{k,i}$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma = \gamma_i$			[0.000]	[0.000]			[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{k,i} = 0$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = 0$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Residuals diagnostics								
equation (9) or (7)								
avg ρ	−0.015	−0.018	0.014	0.016	−0.015	−0.016	0.017	0.016
avg $\|\rho\|$	0.465	0.464	0.367	0.402	0.459	0.459	0.391	0.426
$\mathcal{CD}$	−0.776	−0.962	0.808	0.878	−0.801	−0.856	0.924	0.863
IPS	[0.281]	[0.149]	[0.000]	[0.000]	[0.067]	[0.167]	[0.000]	[0.000]
CIPS	[0.978]	[0.992]	[0.195]	[0.040]	[0.986]	[0.992]	[0.068]	[0.038]
equation (8)								
avg ρ		−0.014		0.025		−0.011		0.028
avg $\|\rho\|$		0.45		0.389		0.428		0.4
$\mathcal{CD}$		−0.701		1.419		−0.553		1.599
IPS		[0.256]		[0.000]		[0.003]		[0.000]
CIPS		[0.959]		[0.805]		[0.096]		[0.008]
equation (6)								
avg ρ	0.011	0.012	0.092	0.119	0.008	0.013	0.106	0.106
avg $\|\rho\|$	0.587	0.582	0.344	0.365	0.609	0.634	0.353	0.353
$\mathcal{CD}$	0.677	0.775	4.893	6.367	0.516	0.834	5.685	5.69
IPS	[0.431]	[0.435]	[0.000]	[0.001]	[0.326]	[0.324]	[0.001]	[0.001]
CIPS	[0.989]	[0.990]	[0.235]	[0.071]	[0.947]	[0.958]	[0.067]	[0.063]

Note: as in table 3.

Table B.3: Estimation of Normalized Supply-Side – TED database – baseline sample

	No mark-up				Mark-up at 10%			
	Homogeneous γ		Heterogeneous γ_i		Homogeneous γ		Heterogeneous γ_i	
equations:	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)
σ	0.923***	0.962***	0.878***	0.882***	0.898***	0.95***	0.829***	0.846***
	(0.024)	(0.003)	(0.034)	(0.003)	(0.031)	(0.004)	(0.044)	(0.004)
ξ	1.001***	1.000***	1.002***	1.002***	1.001***	1.000***	1.002***	1.002***
	(0.024)	(0.003)	(0.034)	(0.003)	(0.031)	(0.004)	(0.044)	(0.004)
γ_l	0.025***	0.02***	0.017***	0.017***	0.02***	0.016***	0.015***	0.015***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
γ_k	−0.018**	−0.01*;"	−0.007	−0.006***	−0.017**	−0.01*	−0.005	−0.006***
	(0.008)	(0.005)	(0.005)	(0.002)	(0.007)	(0.005)	(0.004)	(0.002)
$\mathcal{LL}$	869.327	2153.89	1053.99	2377.79	826.263	2034.07	1014.23	2259.68
$\mathcal{H}_0 : \sigma = 1$	[0.002]	[0.000]	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = \gamma_{k,i}$	[0.001]	[0.001]	[0.002]	[0.000]	[0.001]	[0.001]	[0.001]	[0.000]
$\mathcal{H}_0 : \gamma = \gamma_i$			[0.000]	[0.000]			[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{k,i} = 0$	[0.000]	[0.000]	[0.148]	[0.000]	[0.019]	[0.068]	[0.187]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = 0$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Residuals diagnostics								
equation (9) or (7)								
avg ρ	0.132	0.154	0.267	0.237	0.131	0.155	0.261	0.237
avg $\lvert\rho\rvert$	0.453	0.43	0.477	0.453	0.453	0.43	0.471	0.451
$\mathcal{CD}$	4.911	5.735	9.93	8.82	4.866	5.755	9.71	8.832
IPS	[0.751]	[0.913]	[0.005]	[0.007]	[0.716]	[0.904]	[0.004]	[0.008]
CIPS	[0.985]	[0.974]	[0.034]	[0.071]	[0.981]	[0.970]	[0.029]	[0.078]
equation (8)								
avg ρ		0.174		0.319		0.177		0.327
avg $\lvert\rho\rvert$		0.44		0.485		0.44		0.477
$\mathcal{CD}$		6.49		11.863		6.595		12.189
IPS		[0.717]		[0.012]		[0.700]		[0.004]
CIPS		[0.986]		[0.170]		[0.984]		[0.158]
equation (6)								
avg ρ	0.348	0.365	0.61	0.606	0.305	0.317	0.569	0.552
avg $\lvert\rho\rvert$	0.52	0.524	0.672	0.671	0.53	0.537	0.612	0.597
$\mathcal{CD}$	12.968	13.585	22.718	22.555	11.344	11.788	21.189	20.55
IPS	[0.561]	[0.518]	[0.001]	[0.001]	[0.544]	[0.522]	[0.012]	[0.002]
CIPS	[0.727]	[0.700]	[0.220]	[0.193]	[0.596]	[0.547]	[0.120]	[0.017]

Note: as in table 3.

Table B.4: Estimation of Normalized Supply-Side – TED database – extended sample

	No mark-up				Mark-up at 10%			
	Homogeneous γ		Heterogeneous γ_i		Homogeneous γ		Heterogeneous γ_i	
equations:	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)	(7, 6)	(8,9,6)
σ	0.881***	0.89***	0.985***	0.894***	0.86***	0.872***	0.979***	0.862***
	(0.030)	(0.003)	(0.002)	(0.004)	(0.033)	(0.004)	(0.003)	(0.006)
ξ	1.001***	1.002***	1.018***	1.004***	1.001***	1.002***	1.018***	1.004***
	(0.030)	(0.003)	(0.002)	(0.004)	(0.033)	(0.004)	(0.003)	(0.006)
γ_l	0.02***	0.021***	0.038***	0.027***	0.018***	0.018***	0.031***	0.023***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
γ_k	−0.001	−0.003	−0.025***	−0.011***	−0.002	−0.003	−0.023***	−0.011***
	(0.004)	(0.002)	(0.006)	(0.002)	(0.004)	(0.002)	(0.006)	(0.002)
$\mathcal{LL}$	1416.67	3560.95	2063.5	4280.8	1332.14	3305.64	1988.65	4032.38
$\mathcal{H}_0 : \sigma = 1$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = \gamma_{k,i}$	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma = \gamma_i$			[0.000]	[0.000]			[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{k,i} = 0$	[0.727]	[0.163]	[0.000]	[0.000]	[0.588]	[0.197]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma_{l,i} = 0$	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Residuals diagnostics								
equation (9) or (7)								
avg ρ	0.088	0.073	0.288	0.13	0.09	0.08	0.289	0.132
avg $\lvert\rho\rvert$	0.465	0.449	0.388	0.365	0.463	0.449	0.389	0.366
$\mathcal{CD}$	7.287	6.059	23.806	10.726	7.453	6.604	23.871	10.874
IPS	[0.709]	[0.723]	[0.016]	[0.000]	[0.703]	[0.749]	[0.009]	[0.000]
CIPS	[0.979]	[0.971]	[0.896]	[0.022]	[0.970]	[0.957]	[0.888]	[0.018]
equation (8)								
avg ρ		0.109		0.186		0.115		0.196
avg $\lvert\rho\rvert$		0.486		0.371		0.485		0.371
$\mathcal{CD}$		8.995		15.328		9.473		16.215
IPS		[0.756]		[0.000]		[0.781]		[0.000]
CIPS		[0.991]		[0.001]		[0.990]		[0.001]
equation (6)								
avg ρ	0.215	0.211	0.246	0.355	0.214	0.211	0.226	0.34
avg $\lvert\rho\rvert$	0.585	0.581	0.359	0.5	0.578	0.572	0.352	0.472
$\mathcal{CD}$	17.76	17.421	20.35	29.329	17.644	17.438	18.655	28.062
IPS	[0.610]	[0.629]	[0.000]	[0.001]	[0.455]	[0.458]	[0.000]	[0.000]
CIPS	[1.000]	[1.000]	[0.674]	[0.106]	[1.000]	[0.999]	[0.610]	[0.080]

Note: as in table 3.

C Estimates at the country level

In an analogous fashion to the panel estimation, we provide systematic evidence on the elasticity of substitution between labor and capital at the country level. In particular, we estimate the underlying parameters using:

1. single equation approach. In particular, we consider:
   (a) the linear equation for labor share (equation 8);
   (b) the linear equation for capital share (equation 9);
   (c) the linear equation for relative factor share (equation 7);
2. the three-equation normalized supply-side system combining the logged CES production function (6) withe the linear equations for labor (8) and capital (9). The following form of factor-augmenting technical change are considered:
   (i) constant growth in factor augmentation (equation 10);
   (ii) abrupt break in growth rate of factor augmentation (equation 11);
   (iii) Box-Cox specification (equation 12);
   (iv) trigonometric representation (Fourier expansion) that describe smooth breaks in the form of factor-augmenting technical change (equation 14); .

Akin to the panel estimation we choose the parameter k^L, k^K in the trigonometric presentation and breakpoint $\mathcal{B}_l$ and $\mathcal{B}_k$ that maximizes the likelihood function.

To check stationarity of residuals the usual ADF statistics are calculated and the corresponding number of lags is determined by the BIC criterion. The ADF_1 refers to the equation for the capital share (9) or the relative factor shares (7), the ADF_2 is calculated for the residuals from the equation for the labor share (8) while the ADF_3 captures stationarity of the implied output gap (6).

At the country level, we estimate the distribution parameters π_i. However, fixing it at sample average does not alter our results.

Table C.1: Austria

	Single equation approach			Three-equation system			
	(8)	(9)	(7)	(10)	(11)	(12)	(14)
σ	0.905***	0.859***	0.816***	0.819***	0.962***	0.845***	0.602***
	(0.137)	(0.204)	(0.212)	(0.008)	(0.008)	(0.010)	(0.004)
π	0.322***	0.321***	0.321***	0.321***	0.322***	0.319***	0.321***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
ξ				1.006***	1.008***	1.003***	1.002***
				(0.002)	(0.003)	(0.003)	(0.002)
γ_l	0.061*			0.042***	0.141**	0.043***	0.027***
	(0.065)			(0.001)	(0.026)	(0.002)	(0.000)
γ_k		−0.055*		−0.045***	−0.249*	−0.049***	−0.014***
		(0.092)		(0.003)	(0.054)	(0.005)	(0.001)
γ_{lk}			0.08				
			(0.083)				
λ_l					1.028***		
					(0.100)		
λ_k					0.895***		
					(0.114)		
$\gamma_{l,\mathcal{B}_l}$						0.005***	
						(0.002)	
$\mathcal{B}_l$						1999	
$\gamma_{k,\mathcal{B}_k}$						−0.008***	
						(0.003)	
$\mathcal{B}_k$						2001	
κ_L^{SIN}							−0.023
							(0.004)
κ_L^{COS}							−0.005***
							(0.004)
κ_K^{SIN}							0.038**
							(0.006)
κ_K^{COS}							0.014***
							(0.005)
k^L							2
k^K							2
$\mathcal{LL}$	79.771	59.252	49.062	290.160	292.939	295.625	303.520
$\mathcal{H}_0 : \sigma = 1$	[0.489]	[0.490]	[0.387]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma^K = \gamma^L$			[0.338]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L & γ^K					[0.210]	[0.002]	[0.000]
$\mathcal{H}_0$: const γ^L					[0.778]	[0.001]	[0.000]
$\mathcal{H}_0$: const γ^K					[0.360]	[0.001]	[0.000]
ADF_1		−3.565***	−3.418***	−2.952***	−2.646**	−3.381***	−4.634***
ADF_2	−2.882***			−2.912***	−2.453**	−3.015***	−4.775***
ADF_3				−4.661***	−3.003***	−5.046***	−4.095***

Note: the superscripts ***, ** and * denote the rejection of null about parameters' insignificance at 1%, 5% and 10% significance level, respectively. The expressions in round and squared brackets stand for standard errors and probability values corresponding to respective hypothesis, respectively. The $\mathcal{LL}$ stands for the log likelihood for a given model. For the ADF unit root, the asterisks ***, ** and *, rejection of the null about unit root at the 1%, 5% and 10% significance level.

Table C.2: Belgium

	Single equation approach			Three-equation system			
	(8)	(9)	(7)	(10)	(11)	(12)	(14)
σ	6.623	1.233	4.103	4.678***	0.422***	0.949***	0.894***
	(6.337)	(0.853)	(10.234)	(0.144)	(0.001)	(0.008)	(0.007)
π	0.324***	0.323***	0.324***	0.325***	0.338***	0.329***	0.321***
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
ξ				1.000***	1.005***	1.006***	1.003***
				(0.002)	(0.002)	(0.002)	(0.002)
γ_l	0.016***			0.014***	0.014***	0.090**	0.029***
	(0.000)			(0.000)	(0.000)	(0.012)	(0.002)
γ_k		−0.02**		−0.018***	−0.024***	−0.18**	−0.051***
		(0.018)		(0.001)	(0.001)	(0.027)	(0.005)
γ_{lk}			0.044***				
			(0.003)				
λ_l					0.4***		
					(0.041)		
λ_k					0.554***		
					(0.037)		
$\gamma_{l,\mathcal{B}_l}$						−0.107***	
						(0.016)	
$\mathcal{B}_l$						1984	
$\gamma_{k,\mathcal{B}_k}$						0.219***	
						(0.035)	
$\mathcal{B}_k$						1984	
κ_L^{SIN}							0.139***
							(0.031)
κ_L^{COS}							−0.265***
							(0.024)
κ_K^{SIN}							−0.266***
							(0.064)
κ_K^{COS}							0.51***
							(0.049)
k^L							1
k^K							1
$\mathcal{LL}$	75.832	44.528	39.149	283.727	301.034	300.716	302.084
$\mathcal{H}_0 : \sigma = 1$	[0.375]	[0.784]	[0.762]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma^K = \gamma^L$			[0.000]	[0.000]	[0.000]	[0.003]	[0.000]
$\mathcal{H}_0$: const γ^L & γ^K					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^K					[0.000]	[0.000]	[0.000]
ADF_1		−2.587**	−3.015***	−1.138	−3.001***	−3.681***	−2.452***
ADF_2	−3.595***			−1.870*	−2.979***	−3.567***	−2.484***
ADF_3				−1.745*	−3.070***	−2.814***	−3.726***

Note: as in table C.1.

Table C.3: Denmark

	Single equation approach			Three-equation system			
	(8)	(9)	(7)	(10)	(11)	(12)	(14)
σ	1.706***	0.405***	1.477	0.942***	0.357***	0.432***	0.699***
	(0.380)	(0.080)	(0.958)	(0.014)	(0.002)	(0.004)	(0.009)
π	0.295***	0.293***	0.294***	0.29***	0.315***	0.321***	0.294***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
ξ				1.01***	1.01***	1.019***	1.001***
				(0.004)	(0.003)	(0.003)	(0.003)
γ_l	0.01***			0.073**	0.017***	0.029***	0.025***
	(0.003)			(0.011)	(0.001)	(0.001)	(0.001)
γ_k		−0.031***		−0.159**	−0.028***	−0.04***	−0.042***
		(0.002)		(0.026)	(0.000)	(0.001)	(0.003)
γ_{lk}			0.009				
			(0.046)				
λ_l					0.456***		
					(0.052)		
λ_k					0.667***		
					(0.037)		
$\gamma_{l,\mathcal{B}_l}$						−0.017***	
						(0.001)	
$\mathcal{B}_l$						1998	
$\gamma_{k,\mathcal{B}_k}$						0.016***	
						(0.002)	
$\mathcal{B}_k$						1995	
κ_L^{SIN}							−0.023
							(0.016)
κ_L^{COS}							−0.079***
							(0.011)
κ_K^{SIN}							0.054*
							(0.027)
κ_K^{COS}							0.101***
							(0.020)
k^L							1
k^K							1
$\mathcal{LL}$	65.914	40.503	27.901	238.744	256.086	261.005	254.942
$\mathcal{H}_0 : \sigma = 1$	[0.063]	[0.000]	[0.618]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma^K = \gamma^L$			[0.845]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L & γ^K					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^K					[0.000]	[0.000]	[0.000]
ADF_1		−2.409**	−3.353***	−2.689***	−2.642**	−2.915***	−3.354***
ADF_2	−2.965***			−2.544**	−2.669***	−3.351***	−3.165***
ADF_3				−2.333**	−2.536**	−3.217***	−2.960***

Note: as in table C.1.

Table C.4: Finland

	Single equation approach			Three-equation system			
	(8)	(9)	(7)	(10)	(11)	(12)	(14)
σ	2.898^{*}	0.563^{***}	0.495^{***}	0.705^{***}	0.852^{***}	0.847^{***}	0.69^{***}
	(1.543)	(0.058)	(0.077)	(0.011)	(0.030)	(0.031)	(0.013)
π	0.286^{***}	0.299^{***}	0.3^{***}	0.307^{***}	0.309^{***}	0.303^{***}	0.303^{***}
	(0.004)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.003)
ξ				1.016^{***}	0.979^{***}	0.946^{***}	1.01^{***}
				(0.006)	(0.005)	(0.005)	(0.003)
γ_l	0.017^{***}			0.042^{***}	0.061^{***}	0.037^{***}	0.033^{***}
	(0.003)			(0.002)	(0.008)	(0.007)	(0.003)
γ_k		-0.02^{***}		-0.033^{***}	-0.07^{**}	-0.052^{**}	-0.014^{***}
		(0.005)		(0.004)	(0.018)	(0.017)	(0.003)
γ_{lk}			0.05^{***}				
			(0.007)				
λ_l					1.348^{***}		
					(0.184)		
λ_k					0.917^{***}		
					(0.273)		
$\gamma_{l,\mathcal{B}_l}$						0.038^{***}	
						(0.004)	
$\mathcal{B}_l$						1993	
$\gamma_{k,\mathcal{B}_k}$						-0.02^{***}	
						(0.006)	
$\mathcal{B}_k$						1988	
κ_L^{SIN}							-0.137^{***}
							(0.018)
κ_L^{COS}							0.069^{***}
							(0.013)
κ_K^{SIN}							0.275^{***}
							(0.033)
κ_K^{COS}							-0.015
							(0.025)
k^L							1
k^K							1
$\mathcal{LL}$	76.545	28.762	17.587	175.130	195.934	201.699	215.907
$\mathcal{H}_0 : \sigma = 1$	[0.219]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma^K = \gamma^L$			[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L & γ^K					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L					[0.059]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^K					[0.762]	[0.001]	[0.000]
ADF_1		-2.945^{***}	-2.964^{***}	-2.906^{***}	-2.568^{**}	-2.740^{***}	-3.871^{***}
ADF_2	-1.484			-2.340^{**}	-2.472^{**}	-2.555^{**}	-3.950^{***}
ADF_3				-1.746^{*}	-3.311^{***}	-3.449^{***}	-4.098^{***}

Note: as in table C.1.

Table C.5: France

	Single equation approach			Three-equation system			
	(8)	(9)	(7)	(10)	(11)	(12)	(14)
σ	5.905	0.319**	0.371*	0.671***	0.217***	0.26***	0.465***
	(7.513)	(0.115)	(0.190)	(0.018)	(0.002)	(0.002)	(0.006)
π	0.261***	0.258***	0.258***	0.248***	0.282***	0.292***	0.256***
	(0.003)	(0.004)	(0.004)	(0.003)	(0.002)	(0.003)	(0.001)
ξ				1.003***	1.009***	1.002***	1.001***
				(0.002)	(0.003)	(0.003)	(0.002)
γ_l	0.01***			0.027***	0.016***	0.022***	0.022***
	(0.002)			(0.001)	(0.000)	(0.000)	(0.001)
γ_k		−0.015***		−0.041***	−0.01***	−0.019***	−0.02***
		(0.004)		(0.003)	(0.000)	(0.001)	(0.001)
γ_{lk}			0.028***				
			(0.002)				
λ_l					0.611***		
					(0.041)		
λ_k					0.482***		
					(0.058)		
$\gamma_{l,\mathcal{B}_l}$						−0.007***	
						(0.001)	
$\mathcal{B}_l$						1986	
$\gamma_{k,\mathcal{B}_k}$						0.012***	
						(0.001)	
$\mathcal{B}_k$						1993	
κ_L^{SIN}							0.008
							(0.006)
κ_L^{COS}							−0.041***
							(0.004)
κ_K^{SIN}							0.024***
							(0.008)
κ_K^{COS}							0.077***
							(0.007)
k^L							1
k^K							1
$\mathcal{LL}$	67.577	31.393	23.780	222.080	253.894	274.444	269.623
$\mathcal{H}_0 : \sigma = 1$	[0.514]	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma^K = \gamma^L$			[0.122]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L & γ^K					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^K					[0.000]	[0.000]	[0.000]
ADF_1		−1.552	−1.865*	−1.263	−3.217***	−3.394***	−2.524***
ADF_2	−1.759*			−1.185	−2.625**	−3.998***	−2.130***
ADF_3				−2.729***	−2.604**	−4.342***	−3.013***

Note: as in table C.1.

Table C.6: Germany

	Single equation approach			Three-equation system			
	(8)	(9)	(7)	(10)	(11)	(12)	(14)
σ	0.834***	0.489***	0.4***	0.396***	0.389***	0.399***	0.525***
	(0.130)	(0.045)	(0.035)	(0.001)	(0.001)	(0.001)	(0.002)
π	0.268***	0.267***	0.267***	0.265***	0.269***	0.268***	0.267***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
ξ				0.999***	1.01***	1.019***	1.001***
				(0.003)	(0.004)	(0.003)	(0.002)
γ_l	0.032**			0.023***	0.022***	0.026***	0.025***
	(0.010)			(0.000)	(0.000)	(0.001)	(0.001)
γ_k		−0.032***		−0.03***	−0.03***	−0.028***	−0.037***
		(0.001)		(0.000)	(0.000)	(0.001)	(0.001)
γ_{lk}			0.052***				
			(0.001)				
λ_l					0.802***		
					(0.047)		
λ_k					1.056***		
					(0.048)		
$\gamma_{l,\mathcal{B}_l}$						−0.006***	
						(0.001)	
$\mathcal{B}_l$						1990	
$\gamma_{k,\mathcal{B}_k}$						−0.004***	
						(0.001)	
$\mathcal{B}_k$						1991	
κ_L^{SIN}							0.022***
							(0.006)
κ_L^{COS}							−0.023***
							(0.004)
κ_K^{SIN}							−0.06***
							(0.010)
κ_K^{COS}							0.002
							(0.005)
k^L							1
k^K							1
$\mathcal{LL}$	71.373	54.073	49.047	285.027	293.536	299.022	304.407
$\mathcal{H}_0 : \sigma = 1$	[0.201]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma^K = \gamma^L$			[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L & γ^K					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^K					[0.241]	[0.001]	[0.000]
ADF_1		−3.710***	−4.085***	−3.010***	−3.340***	−3.740***	−3.340***
ADF_2	−2.847***			−2.750***	−3.991***	−4.456***	−4.381***
ADF_3				−2.759***	−3.693***	−4.960***	−4.543***

Note: as in table C.1.

Table C.7: Italy

	Single equation approach			Three-equation system			
	(8)	(9)	(7)	(10)	(11)	(12)	(14)
σ	1.539***	0.36***	0.466***	0.886***	0.971***	0.801***	0.756***
	(0.278)	(0.075)	(0.068)	(0.014)	(0.005)	(0.012)	(0.013)
π	0.266***	0.262***	0.254***	0.263***	0.262***	0.273***	0.263***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
ξ				1.025***	1.028***	1.031***	1.013***
				(0.005)	(0.004)	(0.004)	(0.002)
γ_l	−0.005***			0.059***	0.217**	0.046***	0.018***
	(0.006)			(0.006)	(0.030)	(0.003)	(0.000)
γ_k		−0.025***		−0.144**	−0.575*	−0.099***	−0.042***
		(0.003)		(0.016)	(0.082)	(0.007)	(0.004)
γ_{lk}			0.045***				
			(0.004)				
λ_l					1.194***		
					(0.120)		
λ_k					0.998***		
					(0.124)		
$\gamma_{l,\mathcal{B}_l}$						−0.025***	
						(0.003)	
$\mathcal{B}_l$						2003	
$\gamma_{k,\mathcal{B}_k}$						0.042***	
						(0.007)	
$\mathcal{B}_k$						2003	
κ_L^{SIN}							−0.212***
							(0.013)
κ_L^{COS}							0.012
							(0.011)
κ_K^{SIN}							0.405***
							(0.032)
κ_K^{COS}							−0.095***
							(0.025)
k^L							1
k^K							1
$\mathcal{LL}$	66.122	39.228	31.571	215.253	227.155	232.360	263.546
$\mathcal{H}_0 : \sigma = 1$	[0.053]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma^K = \gamma^L$			[0.022]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L & γ^K					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L					[0.107]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^K					[0.987]	[0.000]	[0.000]
ADF_1		−2.039**	−2.089**	−2.224**	−2.254**	−2.391**	−2.822***
ADF_2	−1.832*			−1.996**	−1.598	−2.509**	−3.079***
ADF_3				−2.912***	−2.941***	−3.628***	−3.862***

Note: as in table C.1.

Table C.8: Japan

	Single equation approach			Three-equation system			
	(8)	(9)	(7)	(10)	(11)	(12)	(14)
σ	1.386^{***}	0.453^{***}	1.201^{**}	0.949^{***}	0.455^{***}	0.507^{***}	0.567^{***}
	(0.155)	(0.041)	(0.484)	(0.007)	(0.002)	(0.004)	(0.005)
π	0.363^{***}	0.362^{***}	0.362^{***}	0.357^{***}	0.38^{***}	0.381^{***}	0.362^{***}
	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
ξ				1.016^{***}	1.021^{***}	1.042^{***}	1^{***}
				(0.006)	(0.007)	(0.004)	(0.004)
γ_l	0.01^{***}			0.122^{**}	0.025^{***}	0.043^{***}	0.035^{***}
	(0.005)			(0.012)	(0.001)	(0.001)	(0.001)
γ_k		-0.023^{***}		-0.186^{**}	-0.021^{***}	-0.029^{***}	-0.029^{***}
		(0.001)		(0.021)	(0.001)	(0.001)	(0.001)
γ_{lk}			-0.032				
			(0.148)				
λ_l					0.432^{***}		
					(0.059)		
λ_k					0.681^{***}		
					(0.063)		
$\gamma_{l,\mathcal{B}_l}$						-0.025^{***}	
						(0.002)	
$\mathcal{B}_l$						1988	
$\gamma_{k,\mathcal{B}_k}$						0.007^{***}	
						(0.001)	
$\mathcal{B}_k$						1984	
κ_L^{SIN}							0.04^{***}
							(0.013)
κ_L^{COS}							-0.1^{***}
							(0.008)
κ_K^{SIN}							-0.033^{***}
							(0.011)
κ_K^{COS}							0.036^{***}
							(0.007)
k^L							1
k^K							1
$\mathcal{LL}$	64.940	53.536	30.937	232.993	252.208	265.139	254.676
$\mathcal{H}_0 : \sigma = 1$	[0.013]	[0.000]	[0.678]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma^K = \gamma^L$			[0.827]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L & γ^K					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^K					[0.000]	[0.000]	[0.000]
ADF_1		-2.885^{***}	-1.671^{*}	-1.412	-4.258^{***}	-5.928^{***}	-3.737^{***}
ADF_2	-1.659^{*}			-1.500	-2.900^{***}	-4.217^{***}	-4.085^{***}
ADF_3				-2.133^{**}	-2.683^{***}	-3.613^{***}	-3.741^{***}

Note: as in table C.1.

Table C.9: The Netherlands

	Single equation approach			Three-equation system			
	(8)	(9)	(7)	(10)	(11)	(12)	(14)
σ	3.307	1.775	0.81***	0.899***	0.65***	0.902***	0.745***
	(3.198)	(1.124)	(0.430)	(0.009)	(0.003)	(0.008)	(0.008)
π	0.302***	0.301***	0.301***	0.307***	0.312***	0.31***	0.298***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)
ξ				0.995***	0.998***	0.995***	1.003***
				(0.003)	(0.003)	(0.003)	(0.003)
γ_l	0.009***			0.019***	0.014***	0.064***	0.028***
	(0.001)			(0.004)	(0.001)	(0.006)	(0.001)
γ_k		0.004***		−0.021***	−0.009***	−0.143**	−0.043***
		(0.009)		(0.009)	(0.001)	(0.015)	(0.002)
γ_{lk}			0.03				
			(0.038)				
λ_l					0.434***		
					(0.062)		
λ_k					−0.469***		
					(0.075)		
$\gamma_{l,\mathcal{B}_l}$						−0.05***	
						(0.009)	
$\mathcal{B}_l$						1984	
$\gamma_{k,\mathcal{B}_k}$						0.132***	
						(0.020)	
$\mathcal{B}_k$						1984	
κ_L^{SIN}							0.145***
							(0.017)
κ_L^{COS}							−0.045***
							(0.010)
κ_K^{SIN}							−0.305***
							(0.039)
κ_K^{COS}							0.158***
							(0.023)
k^L							1
k^K							1
$\mathcal{LL}$	64.509	38.746	31.258	244.653	282.276	265.260	259.576
$\mathcal{H}_0 : \sigma = 1$	[0.471]	[0.491]	[0.195]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma^K = \gamma^L$			[0.000]	[0.003]	[0.000]	[0.113]	[0.000]
$\mathcal{H}_0$: const γ^L & γ^K					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^K					[0.000]	[0.000]	[0.000]
ADF_1		−3.032***	−4.726***	−3.418***	−3.181***	−2.739***	−2.936***
ADF_2	−3.206***			−3.519***	−2.895***	−2.791***	−4.161***
ADF_3				−2.122**	−1.881*	−3.214***	−3.426***

Note: as in table C.1.

Table C.10: Spain

	Single equation approach			Three-equation system			
	(8)	(9)	(7)	(10)	(11)	(12)	(14)
σ	1.276***	0.423***	0.958***	0.979***	0.998***	0.958***	0.722***
	(0.184)	(0.058)	(0.423)	(0.003)	(0.001)	(0.007)	(0.007)
π	0.35***	0.349***	0.35***	0.343***	0.351***	0.341***	0.35***
	(0.004)	(0.003)	(0.004)	(0.002)	(0.003)	(0.002)	(0.002)
ξ				1.035***	1.042***	1.047***	1.002***
				(0.003)	(0.003)	(0.003)	(0.002)
γ_l	0.001***			0.19**	1.324	0.094**	0.025***
	(0.005)			(0.017)	(0.432)	(0.015)	(0.001)
γ_k		−0.02***		−0.361**	−2.456	−0.163**	−0.043***
		(0.001)		(0.033)	(0.802)	(0.030)	(0.002)
γ_{lk}			0.153				
			(1.349)				
λ_l					0.296***		
					(0.073)		
λ_k					0.214***		
					(0.074)		
$\gamma_{l,\mathcal{B}_l}$						0.004*	
						(0.002)	
$\mathcal{B}_l$						1999	
$\gamma_{k,\mathcal{B}_k}$						−0.035***	
						(0.006)	
$\mathcal{B}_k$						1992	
κ_L^{SIN}							0.165***
							(0.017)
κ_L^{COS}							−0.113***
							(0.010)
κ_K^{SIN}							−0.245***
							(0.024)
κ_K^{COS}							0.053***
							(0.014)
k^L							1
k^K							1
$\mathcal{LL}$	56.338	44.563	26.184	262.212	270.325	268.325	279.643
$\mathcal{H}_0 : \sigma = 1$	[0.135]	[0.000]	[0.921]	[0.000]	[0.016]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma^K = \gamma^L$			[0.000]	[0.000]	[0.002]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L & γ^K					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L					[0.000]	[0.062]	[0.000]
$\mathcal{H}_0$: const γ^K					[0.000]	[0.000]	[0.000]
ADF_1		−2.411**	−3.053***	−1.915*	−2.103**	−1.873*	−3.131***
ADF_2	−2.375**			−1.967**	−2.152**	−1.945*	−3.463***
ADF_3				−2.048**	−2.521**	−2.111**	−3.458***

Note: as in table C.1.

Table C.11: The United Kingdom

	Single equation approach			Three-equation system			
	(8)	(9)	(7)	(10)	(11)	(12)	(14)
σ	0.999***	0.58***	0.804*	0.982***	0.744***	0.718***	0.943***
	(0.000)	(0.149)	(0.422)	(0.008)	(0.009)	(0.012)	(0.008)
π	0.278***	0.277***	0.277***	0.284***	0.286***	0.268***	0.279***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)
ξ				1.023***	1.027***	1.006***	1.018***
				(0.004)	(0.003)	(0.003)	(0.004)
γ_l	−2.925***			−0.089**	0.013***	0.015***	−0.002**
	(0.000)			(0.029)	(0.000)	(0.002)	(0.010)
γ_k		−0.014***		0.261*	0***	0.008***	0.044**
		(0.004)		(0.073)	(0.000)	(0.003)	(0.010)
γ_{lk}			0.019				
			(0.062)				
λ_l					0.226**		
					(0.101)		
λ_k					−3.167		
					(4.744)		
$\gamma_{l,\mathcal{B}_l}$						0.005***	
						(0.002)	
$\mathcal{B}_l$						1989	
$\gamma_{k,\mathcal{B}_k}$						−0.027***	
						(0.003)	
$\mathcal{B}_k$						1987	
κ_L^{SIN}							0.455***
							(0.064)
κ_L^{COS}							−0.261***
							(0.039)
κ_K^{SIN}							−1.167***
							(0.160)
κ_K^{COS}							0.656***
							(0.094)
k^L							2
k^K							2
$\mathcal{LL}$	57.601	32.671	22.807	233.431	241.011	251.129	255.561
$\mathcal{H}_0 : \sigma = 1$	[0.024]	[0.005]	[0.641]	[0.030]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma^K = \gamma^L$			[0.755]	[0.001]	[0.000]	[0.000]	[0.001]
$\mathcal{H}_0$: const γ^L & γ^K					[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L					[0.000]	[0.001]	[0.000]
$\mathcal{H}_0$: const γ^K					[0.380]	[0.000]	[0.000]
ADF_1		−2.769***	−3.143***	−3.063***	−2.662***	−3.680***	−2.782***
ADF_2	−3.120***			−3.132***	−2.636**	−3.715***	−2.999***
ADF_3				−3.801***	−2.924***	−3.330***	−5.599***

Note: as in table C.1.

Table C.12: The United States

	Single equation approach			Three-equation system			
	(8)	(9)	(7)	(10)	(11)	(12)	(14)
σ	0.878***	0.538***	0.453***	0.485***	0.512***	0.506***	0.461***
	(0.134)	(0.048)	(0.044)	(0.001)	(0.001)	(0.001)	(0.001)
π	0.309***	0.309***	0.309***	0.31***	0.312***	0.312***	0.312***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ξ				1.001***	0.997***	0.991***	1.001***
				(0.003)	(0.004)	(0.003)	(0.000)
γ_l	0.031**			0.023***	0.023***	0.021***	0.024***
	(0.013)			(0.000)	(0.000)	(0.000)	(0.000)
γ_k		−0.017***		−0.016***	−0.017***	−0.02***	−0.017***
		(0.001)		(0.000)	(0.001)	(0.001)	(0.000)
γ_{lk}			0.037***				
			(0.001)				
λ_l					1.061***		
					(0.059)		
λ_k					0.81***		
					(0.079)		
$\gamma_{l,\mathcal{B}_l}$						0.004***	
						(0.001)	
$\mathcal{B}_l$						2003	
$\gamma_{k,\mathcal{B}_k}$						0.006***	
						(0.001)	
$\mathcal{B}_k$						1998	
κ_L^{SIN}							0.021***
							(0.005)
κ_L^{COS}							0.002
							(0.004)
κ_K^{SIN}							−0.02***
							(0.004)
κ_K^{COS}							0.015***
							(0.004)
k^L							1
k^K							2
$\mathcal{LL}$	74.490	61.738	53.041	306.130	307.571	316.525	322.555
$\mathcal{H}_0 : \sigma = 1$	[0.362]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0 : \gamma^K = \gamma^L$			[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L & γ^L					[0.055]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^L					[0.302]	[0.000]	[0.000]
$\mathcal{H}_0$: const γ^K					[0.016]	[0.000]	[0.000]
ADF_1		−3.089***	−3.186***	−2.961***	−2.725***	−2.651**	−3.827***
ADF_2	−2.498**			−2.359**	−2.308**	−3.024***	−4.077***
ADF_3				−2.785***	−2.618**	−3.345***	−4.940***

Note: as in table C.1.