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Estimating the Lagged Response of Profitability on Labour Ratio

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This paper investigates recent trends of production factor – including both capital and labour – ratios in the EU-27 based on national accounts data. These output elasticities are typically expected to be constant, however, both theoretically and empirically, these assumptions are frequently violated for a variety of reasons.
In this paper a lagged response is introduced and investigated: changes of profitability can affect labour force adjustments with a delay. Granger causality tests confirm lagged behaviour. Structural VAR estimations show the strongest impact over the span of two to five quarters and the effect is moderate.

Keywords: Labour Ratio, Capital Ratio, Macroeconometrics, VAR

JEL Classifications: E220, E230, C320

1 Introduction

The structure of production factors is a frequently discussed in the literature. In the standard model, production factor shares, namely labour-to-income and capital-to-income ratios are kept constant. These results are empirically grounded in the work of Káldor (1963). Many papers, however, (e.g. Jones, 2003; Gollin, 1998) found trends in factor shares. Many factors can trigger time dependent elasticities: e.g. marginal costs of production factors may vary as a result of evolution of different taxes levied on capital and labour.

In this paper another reason for time-varying labour ratio is investigated based on standard econometric techniques, called lagged adjustment. It is assumed that the impact of profitability fluctuations on labour force adjustments is not immediate but followed with some delay. However, this delay could be shorter in a crisis era.

Capital and labour shares are usually derived from micro data. In this paper national accounts data are used: although GDP income side items (based on ESA[1] 2010 methodology) are aggregated and partly determined on residual basis, these might have better data quality.

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[1] European System of National and Regional Accounts (ESA)

These data are available on a quarterly basis and are reported only with a very short delay (~t+65 days), consequently, these are more up-to-date than micro data reported with a few years of delay. In addition, national account adjustments (e.g. accrual correction) are also taken into account and all sectors are represented (i.e. financial corporations and government activities are also included) in the ESA framework. Micro data typically exclude material sectors like financial institutions, thus, ignoring important channels. National accounts data are also harmonized within the EU and are revised frequently. Consequently, by excluding national account corrections and adjustments, estimations based on micro data might be biased. Note that there is a trade-off: the sample size could be smaller and data could be impacted by cross sectional and time heterogeneity when aggregated national accounts data are used. Hence, we have to control for these potential shortcomings.

The paper is structured as follows. The next section presents the methodology including theoretical framework and literature overview. Section 3 is dedicated to empirical research including testing and estimating lagged adjustment. Section 4 concludes the findings of this paper.

2 Methodology: Theory and Empirics

2.1 Theoretical foundations

Let us consider the classic Cobb-Douglas production function:

$$Y_t = f(T_t, K_t, L_t) = T_t K_t^{\alpha} L_t^{1-\alpha}, \text{ where } 0 < \alpha < 1 \quad (1)$$

Y is GDP, *T* is level of technology, *K* is capital and *L* stands for labour in time *t*.

It is widely believed that capital-to-income and labour-to-income ratios are roughly constant in time, which can easily be derived by taking first derivatives: capital-to-income ratio equals to α, while labour-to-income ratio to $1 - \alpha$. The elasticity of substitution between capital and labour is 1 but a more general, Constant Elasticity of Substitution (CES) production function can also be generated, for which this does not holds automatically:

$$Y_t = f(K_t, L_t) = T\left[a(bK_t)^{\psi} + (1-a)\big((1-b)L_t\big)^{\psi}\right]^{\frac{1}{\psi}}, \text{ where } 0 < a, \text{ b<1} \quad (2)$$

Note that the Inada (1963) conditions are violated, when $0 < \psi < 1$, leading to endogenous growth. Also, when ψ approaches 0 to the limit and $a = \alpha$, we get the Cobb-Douglas formula.

One limitation of the Cobb-Douglas production function is that the structure of production is not changing in time, while empirical research suggests the opposite under certain conditions (see next section). By endogenizing factor ratios, longer trends can be captured like higher capital ratio due to industrialization, or to put it differently, various observations and concepts related to increasing or diminishing returns, such as poverty traps or convergence clubs. Moreover, this is one way to capture the impact of technological progress on the production function (Ligeti, 2002).

In this paper a lagged adjustment is introduced, assuming that profit shocks impact labour income with some delay. Models that incorporate time-varying elasticities may capture this dynamic process, in particular, when we do not assume an exogeneous path for the factor ratios but rather endogenize those. One approach of endogenous production factors is proposed by Ligeti (2002):

$$Y_t = TK_t^{\alpha_t} L_t^{1-\alpha_t}, \text{ where } \alpha_t = 1 - \frac{1}{(K_t/L_t)} = 1 - exp\left[- ln\left(\frac{K_t}{L_t}\right)\right] \text{ and} \quad (3)$$

$$ln\left(\frac{K_t}{L_t}\right) = ln(k_t) > 0 \Leftrightarrow k > 1; 0 < \alpha_t < 1, \forall t$$

In this model the factor shares are time-varying, and are linked to production factors: higher capital leads to higher capital-to-income ratio. A key assumption of the model is that the countries under consideration are developed economies, as capital exceeds labour volume and the contribution of capital is increasing, empirically driven by industrialization. Both stable or unstable solutions exist for this model [2].

One way to incorporate lagged adjustment is to modify (3) by assuming a lagged relationship between the production factors and the capital ratio in (4). An increase in capital in time *t* may not have an immediate impact on the elasticity, only with some transmission lag. Another modification involves adding a shock parameter (ϵ), which represents various idiosyncratic events, such as profit shocks. Finally, labour rigidities are added (θ) to control for sluggish labour force adjustments, which can also lower the impact of the shock parameter on capital elasticity.

$$\alpha_t = 1 - \frac{1}{\left(\frac{K_{t-1}}{\left(\frac{1}{1-\theta}\right) L_{t-1}}\right)} \cdot \left(\frac{1}{\epsilon}\right), \text{ where: } 0 < \epsilon < 1 \; and \; 0 < \theta < 1 \quad (4)$$

[2] Stable or unstable / endogenous growth can also be achieved, and capital accumulation may exceed labour accumulation in the long run. In order to get locally and asymptotically stable results including transition dynamics and conditional convergence, the following assumptions have to be fulfilled (Ligeti, 2002):

$$sT\, exp\left(\frac{-1}{e}\right) < n + \delta \text{ and } 1 < k_1^* < e, \text{ where } k_1^* \text{ stands for stable steady state} \quad (5)$$

In this model household behaviour and wage dynamics are not incorporated, however, wage rigidities also exist in practice. Further extensions of the production function exist, including endogenous factor ratios [3].

2.2 Literature Overview

As argued in the previous section, production factor shares are usually kept constant. This idea came from Káldor (1963), who summarized six stylized facts, including this one. Since then Káldor's findings were extended by conditional convergence (Barro and Sala-i-Martin, 1991; 2004) and further stylized facts (Jones and Romer, 2010). However, the six original facts remained unchanged in mainstream economics.

In mainstream economics, elasticities are considered to be constant for many reasons. In case of a positive (negative) demand shock, companies recruit more (less) workers but they are also equipped with more (less) capital. Factors influencing elasticities (e.g. factor prices) may also change similarly. As Zuleta (2008) argues, another reason for constant elasticities is the fact that capital income also includes land income, while labour income includes both raw labour and human capital, and changes of these components could offset each other.

There is also evidence for time-varying elasticities. Investment trends are usually volatile, for instance, due to the cyclical nature of governmental measures or EU transfers. However, labour trends are often found to be relatively smooth, due to the risk aversion of employees and the rigidity of salaries. Solow (1958) argued that factor shares are not absolute but rather *relative constant*, meaning that these can show minor trends. Aukrust and Birke (1959) also noted that the empirical measurement of elasticities depends on the *sample size*.

Among others, Jones (2003) argued that the capital share may have a trend, because *prices of equipment fell* compared to the price of non-durable goods. Hall and Jones (1999) demonstrated that differences of *social infrastructure*[4] cause variation in capital accumulation, together with educational attainment and productivity.

In case of labour trends, wages do not automatically equal to marginal products, meaning "changes in factor shares could reflect changes in the markup or changes in bargaining power"

[3] Tarján (2010) also shows a model with endogenous, time dependent dynamics of α, which is a function of initial and final savings, depreciation of human capital, steady state growth rate and scale of economic decline resulting from Jánossy's (1966) trendline theory. As Tarján argues, Jánossy's theory underlines the importance of human and physical capital ratios because the deviation of the fractions from the steady state leads to accelerating growth dynamics.

Capital may also cover omitted variables, like human capital (e.g. Mankiw et al., 1990), or savings. AK-type endogenous models can also be constructed, followed by Romer (1986), Lucas (1988), Arrow (1962) and Sheshinski (1967), which do not usually result in transition dynamics, because the return on capital is not diminishing. Multiproduct models, following Spence (1976) and Dixit-Stiglitz (1977) can also be formulated.

[4] Defined by Hall and Jones (1999, 2) as follows: "institutions and government policies that determine the economic environment within which individuals accumulate skills, and firms accumulate capital and produce output".

(Jones, 2003, 10). Gollin (1998) also showed that labour ratio can be country specific. Similarly, Charpe et al. (2020) noted that labour share exhibits long swings.

According to Piketty (2014) when the *GDP growth rate (g) is low* compared to the rate of return on capital (r>g), wealth gain is driven by accumulation of capital, rather than accumulation of labour. At the same time, the wealthiest people of a society benefit mostly from it. This leads to an even higher inequality calling for governmental action.

Evidence was also found that there is a positive correlation between the ratios of reproducible factors (i.e. physical and human capital), the *relative abundance* of factors and the income per capita (Zuleta, 2008). The *Heckscher-Ohlin theory* and *location specific effects* can also explain some variation of factor shares: firms producing labour (or capital-) intensive goods are likely to invest in labour (or capital) abundant economies (Zuleta, 2008).

Researchers tested and estimated both production factor shares and *returns to scale*. Many economists estimated constant returns to scale, for instance Durand (1937) and Douglas (1948). Other researchers, among others Aukrust and Birke (1959), Kuhilo (1962) and Walters (1963) argued that the assumption of constant returns is often violated. One major reason for this restriction is mathematical simplification.

Estimated values of α – often based on micro data – also vary, but typically it is assumed that it is around 1/3. Cobb and Douglas (1928), Douglas (1934) and Durand (1937) estimated α to be around 1/4, while for example Solow (1957) and Intriligator (1965) estimated much smaller α: about 10 – 15%. However, many empirical results are measured from U.S. data. This paper focuses on EU member states, therefore, European data are of greater importance. Based on estimations related to output gaps, the European Commission estimated 0.37 for α (Havik, et al. 2014).

To summarize, there is empirical evidence that factor shares are not always constant. These findings also imply that the elasticity of substitution is not always one. Numerous studies have presented findings both supporting (e.g. Fuchs (1963), Berndt (1976), Fisher (1971)) and questioning the use of the Cobb-Douglas production function (e.g. Antras (2004), Samuelson (1928)[5]).

2.3 Further Reasons of Non-constant Behaviour

Generalized facts

As argued in section 2.1, in the standard economic framework α is kept constant, but there are some extensions, which lead to endogenous elasticities. Some empirical results shown in

[5] Samuelson also pointed out that regression results showing a constant scale (and confirming the Cobb-Douglas production function) demonstrate an accounting identity. This also means that estimation of output elasticities might be biased.

section 2.2 also indicate that the ratios are time-varying. Both volumes (capital and labour) and prices (real wages and real yields) – i.e. marginal products and costs – can change at different rates because they are subject to various trends. Hence, factor shares are impacted by fundamentals (in the long run) or shocks (in the short run).

Technological progress and efficiency may impact savings rate and α differently during the course of time. In the era of industrialization, which was primarily[6] driven by the technological change, production factor ratios surely changed, because corporations could produce more output with the new, invested capital. Recent innovation trends also underline that production factor ratios can be time-varying.

Growth fundamentals, including *institutions* may have an impact on factor shares, which can be outlined in the neoclassical framework to some extent (Hall and Sobel and Crowley, 2010; Grigorian and Martinez, 2000; Tebaldi and Mohan, 2008; Polimeni et al., 2007). In general, institutions are thought to be persistent but institutions can have an impact not only on the capital share, but also on demographic and labour trends (e.g. how many hours people work).

In order to redistribute income, *government policies* generate taxation trends of labour and capital. This process has an impact on the accumulation of production factors, because taxes levied on factors and tax allowances can vary. *Globalization* tendencies, including removal of trade barriers in the last decades can also stimulate certain shifts in the factor shares. This is mainly due to the free movement of production factors and the increasing competition (also in tax rates), which influence market conditions.

Capital and labour accumulation as well as amortization trends are *branch specific*, as some sectors need more capital or labour, while others need less to produce goods and services. The industrial output is usually capital intensive, while services are labour intensive. The contribution of agriculture and industry to GDP is typically high in developing countries, while services have usually a much higher contribution in developed economies. However, the capital per labour force ratio is usually higher in developed countries and segments. Recent evidence also suggests the existence of time-varying factor ratios as a result of economic transition: Zhang et al. (2019) highlighted that the ratios are not constant in developing economies. In summary, the level of development may have an impact on income ratios.

Not only long-term fundamentals and proxies, but short-term shocks might also have impact on capital and labour accumulation. Let us assume that an open economy faces a positive external price shock. Due to rigidities and fixed nominal payments, real wages are assumed to

[6] There are many other factors that also contributed to industrialization. 1) A scale effect, a certain level of population and technology could have been essential for accelerating growth trends. (Acemoglu, 2008) 2) Agricultural nations reached probably their maximum output prior the revolution. (Kim – Heshmati, 2014) 3) Industrialization offered a solution for countries that had fewer natural resources necessary to catch up. (Acemoglu, 2008) 4) Protestantism could have been one reason for capitalism and industrialization. (Weber, 1930)

grow due to lower imported inflation. Let us assume that the import content of durable goods is not so high compared to consumption goods, hence, the overall effect on the investment deflator would be probably smaller compared to consumer prices (which are basically impacting wages). At the same time, lower inflation also boosts domestic demand resulting in higher profit, which also supports capital and labour growth. As corporations would face lower transportation costs due to smaller inflation, they are inspired to invest more and hire more employees, too. Hence, *openness and the import content* of goods / services also matters, as consumer prices and investment deflators are impacted differently by the respective shocks. Other shocks can also impact shares, e.g. shocks having an impact on risk premium stimulate companies to accumulate more or less capital or labour.

Lagged adjustment

In this paper another reason, a *lagged response* is tested. The assumption is that when profitability and profit outlook changes, companies modify their labour demand with some delay, resulting in an employment increase or decline some quarters later. Therefore, there is an adjustment period which leads to a shift in the production factor shares. This lag is due to both internal and external reasons: data are available with some delay or preliminary data might be subject to measurement error, i.e. corporations do not notice changes of profitability immediately. Decision on lay-off or recruitment also takes time, firms find new employees only with some time lag, and the notice period itself increases the lag.

In general, rigidities on the labour side exist, while capital share can change in a more flexible way. Rigidities exist due to demand and supply side factors but case of this particular response demand side factors could be of greater relevance, considering that the adjustment is mostly driven by firm policy, information asymmetry, transmission lag associated with firm decision, or external factors. Institutions also have an impact on rigidities.

Theoretical foundations also provide rationale for lagged adjustment, namely, labour market adjustments can be sluggish due to wage rigidities. According to efficiency wage models (Akerlof, 1982) wages are higher than the market-clearing wage, hence, wages may not change when labour demand decreases. Wages might also be high due to the turnover rate (Stiglitz, 1974): higher wages lower the expenditure related to hiring and training of new comers, which also leads to wage rigidities. Similarly, based on the insider-outsider theories, rigidities are driven by labour turnover costs and the ability of fully-fledged employees to exercise influence over their wages (Lindbeck and Snower, 1987).

This adjustment is assumed to be temporary, due to several reasons. The shock leading to improving (or deteriorating) profit expectations will not probably last for a long period. Profit expectations are also assumed to adapt. Furthermore, as more (or fewer) jobs created based on a promising (or gloomy) profit outlook, labour demand and company costs will be higher (or lower), consequently, the profitability will also change. This means that factor shares are expected to be roughly constant again in the steady state.

3 Empirical Analysis

3.1 Data

In this paper, proxies of capital and labour share are measured from GDP income side items using national accounts (ESA) – Eurostat data, which are available from Q1 1995 to Q4 2023. In national accounts, GDP growth is split into three components on the income side: compensation of employees, gross operating surplus and certain tax revenues. The latter item includes net taxes on production and products (mainly VAT). For further details see App 1.

Additionally, GDP per capita and GDP deflator data were also taken from Eurostat, which were available from Q1 1996 to Q4 2023, while consumer price index was available from Q1 2000 to Q4 2023. Quarterly government non-financial statistics were used to derive taxes on capital and labour – data were available from Q1 2002 to Q3 2023.

EU-27 aggregated data were used for estimating baseline models. For robustness check, models were estimated using panel data: all individual country data were taken into account from Q1 1995 to Q4 2023. To control for cross sectional and time heterogeneity, fixed effects have been applied: data were demeaned with respect to individual and time fixed effects.

All data are from Eurostat (2024).

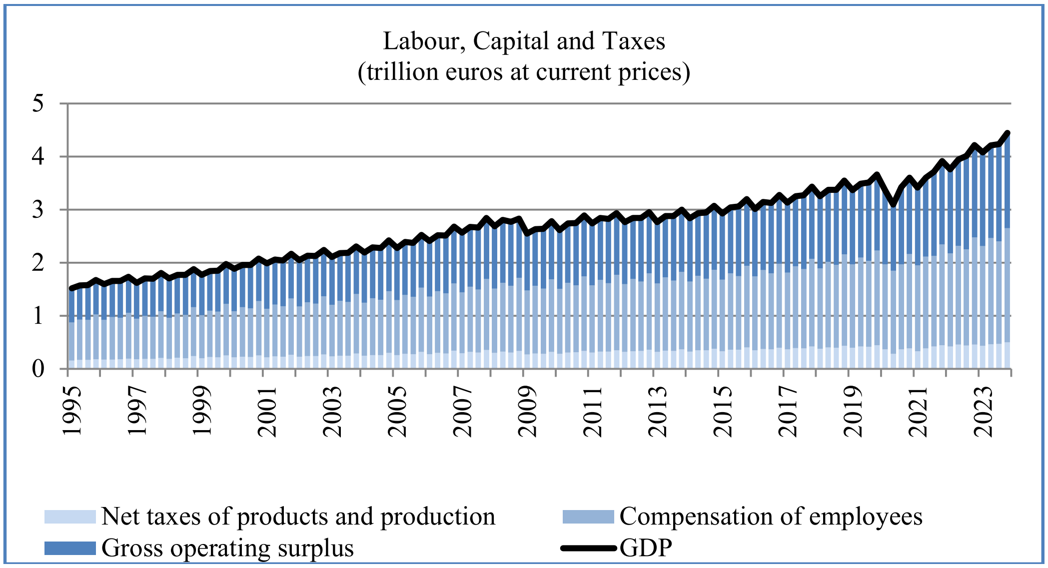
3.2 Descriptive Analysis

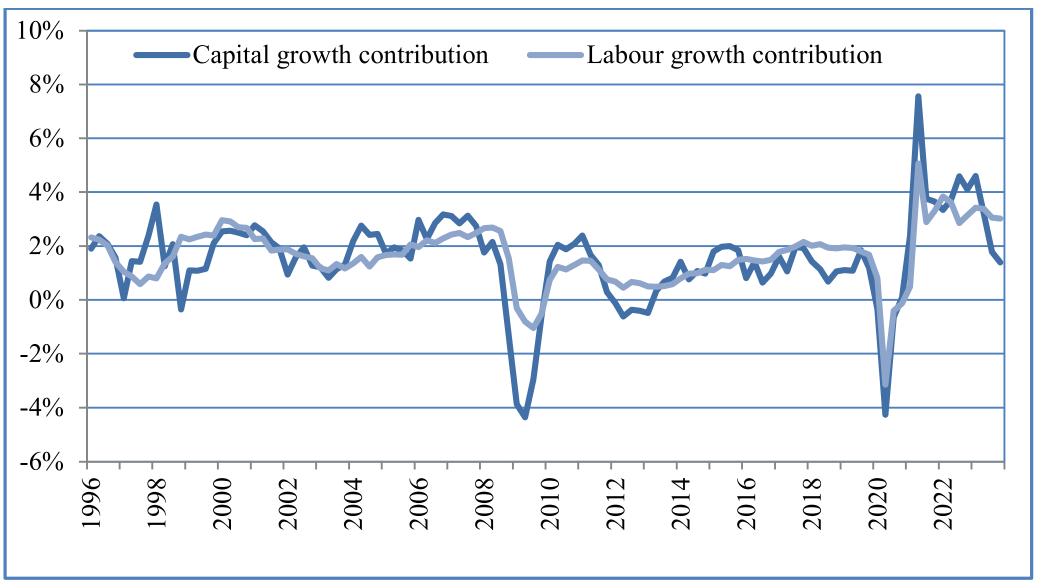
Figure 1 demonstrates the distribution of income side components in the European Union (27 member states) based on quarterly national account data. The ratio of gross operating surplus amounts to roughly 40%, which tends to be slightly higher than the usual estimates of α, but aligns with the calculations of the European Commission (Havik et al., 2014). The share of compensation of employees is approximately 50%, while taxes are around 10%. All three factors increased similarly, so income ratios remained roughly unchanged.

Income shares have unit roots, instead of taking first differences quarterly growth contributions were calculated the following way to make the series stationary:

$$\begin{aligned} Growth\ contributions&: GDP_{t,q}^{Capital} + GDP_{t,q}^{Labour} + GDP_{t,q}^{Taxes} = \\ &= \frac{\left(GDP_{t,q}^{Capital} - GDP_{t-1,q}^{Capital}\right)}{GDP_{t-1,q}} + \\ &+ \frac{\left(GD\ _{t,q}^{Labour} - GDP_{t-1,q}^{Labour}\right)}{GD\ \ _{t-1,q}} + \frac{\left(GDP_{t,q}^{Taxes} - GDP_{t-1,q}^{Taxes}\right)}{GDP_{t-1,q}} = GDP_{t,q}/GDP_{t-1,q} \end{aligned} \tag{6}$$

Figure 1: Decomposition of GDP on the income side in the EU 27





where *Capital* stands for gross operating surplus, *Labour* for compensation of employees, *Taxes* for net taxes of production and products in year *t* and quarter *q*. Contributions are estimated based on current prices as volumes are not available.

3.3 Testing Lagged Adjustment of Profitability

In the following section, the lagged response of profitability on labour share is tested. Cross correlations based on growth contributions confirm lagged impacts and Granger causality tests with lags up to eight also confirm that profitability Granger causes labour contribution.

However, this relation is typically one-sided (Table 1). Granger causality confirms predictability, hence, profitability contains sufficient information to forecast the labour ratio, i.e. lagged adjustment takes place. To verify robustness, Granger causality was estimated using panel data, showing similar results.

3.4 Framework for Estimating Lagged Adjustment by SVAR

Variables

In the previous section the lagged response of profitability on labour force adjustments was confirmed, however, the analysis did not control for additional variables. Thus, a structural VAR model is estimated by controlling for the main drivers available[7]. Due to the relatively small number of data and due to the high number of restrictions needed the following drivers have been considered:

Table 1: Cross correlation and Granger causality of factor ratios (growth contributions)

Lag	Time series data				Panel data			
	Labour and Capital cross correlations		Labour does not Granger cause Capital	Capital does not Granger cause Labour	Labour and Capital cross correlations		Labour does not Granger cause Capital	Capital does not Granger cause Labour
	Lag of Labour	Lag of Capital			Lag of Labour	Lag of Capital		
0	0.79 ***	0.79 ***	-	-	0.43 ***	0.43 ***	-	-
1	0.49 ***	0.74 ***	7.24 **	13.79 ***	0.26 ***	0.44 ***	0.56	99.33 ***
2	0.26 ***	0.62 ***	2.95	8.54 ***	0.12 *	0.39 ***	16.43 ***	49.23 ***
3	0.06 *	0.48 ***	1.53	5.14 **	0.03	0.32 ***	6.45 ***	26.44 ***
4	-0.11 *	0.27 ***	1.37	3.71 **	-0.05 *	0.19 **	6.75 ***	23.21 ***
5	-0.07 *	0.16 **	1.73	2.85 *	-0.01	0.14 *	10.49 ***	20.96 ***
6	-0.09 *	0.11*	1.81	2.34 *	0.01	0.10 *	9.21 ***	16.09 ***
7	-0.09 *	0.07 *	1.51	2.74 *	0.01	0.07 *	8.47 ***	14.49 ***
8	-0.14 *	0.02	1.09	2.19 *	-0.01	0.05 *	10.76 ***	12.97 ***

Note: statistical significance is denoted as follows: 0.1% (***), 1% (**), 5% (*).

[7] The number of parameters estimated is practically smaller than one third of the number of the data (T), i.e.: $np<T/3$, where n stands for the number of variables and p for number of lags. It means that roughly 30 parameters have to be estimated for each equation. As we have quarterly data, p is expected to equal to 4, meaning that maximum ca. 7 endogenous variables can be practically incorporated.

Capital and labour income growth contributions as defined in section 3.2 (two endogenous variables; capital_gc_eu, labour_gc_eu). Ratios were rescaled such that their values are close to 1: rescaled ratio=(ratio+100)/100. By normalizing data with the previous year's GDP, models based on growth contributions could have better properties (i.e. residuals would more likely be homoscedastic and normally distributed). It is important to note that the sum of the normalized items amounts to the annualized quarterly nominal GDP growth (see section 3.2). Note, however, that net taxes of production/products are excluded from the models. Growth contributions are stationary at standard significance levels (see: Table 2 in the Appendix).

Taxes on production factors (two endogenous variables; tax_inc, tax_cap): taxes on labour (tax_inc) are defined as net social contribution, while taxes on capital as taxes on products excluding VAT (tax_cap). Both are expressed as percentage of GDP, and these are receivables of the general government. Note that several tax items exist in national accounts, which might impact the factor shares differently (see: section 2). Guidelines from the European Commission were used as a benchmark to derive labour and capital taxes from national accounts (see European Commission, 2023), but several components had to be excluded from this analysis, because all individual taxes on production factors were not available on quarterly basis. For instance, personal income tax and profit tax were not available separately, only together as taxes on income, therefore, the component has been excluded. The rationale was to focus only on those items that directly impact capital or labour but not both.

Difference of GDP deflator and harmonized consumer prices in percentage points (one endogenous variable; GDPDEFL_CPI): price shocks could impact contributions differently (as discussed in section 2). Labour income might depend on consumer prices, while capital income could rather depend on the GDP deflator. Assuming arbitrage free pricing in the long run, it can be argued that the deviation of prices is stationary, which is also confirmed by the unit root tests (see: Table 2 in the Appendix). Following the classical dichotomy, the price difference probably does not have any impact on other variables in the long-run.

Productivity and structure of GDP (one endogenous variable; PROD): as noted in section 2, branch specific factors can impact income ratios. To control for these factors, the relative variance (standard deviation / average) of the member states was estimated, based on GDP per capita measured in Euro / capita. Hence, the variable can be interpreted as an indicator of convergence: lower variance yields stronger convergence.

Seasonal dummies, intercept and deterministic trend (five exogenous variables) were introduced to control for seasonality, average impact of omitted variables and persistency.

Equations

The VAR has the following unrestricted form:

$$(Y_t) = b_1 \cdot (Y_{t-1}) + b_2 \cdot (Y_{t-2}) + b_3 \cdot (Y_{t-3}) + b_4 \cdot (Y_{t-4}) + c \quad (7)$$

where: Y = taxes on labour (log difference), taxes on capital (log difference), difference of GDP deflator and CPI, capital and labour growth contribution (log), productivity (log difference), c = exogenous variables (constant, seasonal dummies and deterministic trend).

Based on information criteria (SIC) four lags were used, which is common, considering we have quarterly data.

Restrictions

In order to identify the structural model from the unrestricted VAR, restrictions are needed, which were defined as short-run zero restrictions, i.e. most variables were not impacting each other immediately, only with some lag. As Blanchard and Quah (1989) demonstrated, short-run responses can be expressed as long-run ones. The following assumptions were applied to identify the VAR model:

Model 1, large-scale VAR model (M 1 baseline):

(1) Taxes on production factors are[8] not impacted immediately by the variables in the system. The rationale is that these variables are exogenous and primarily set by fiscal policy. Note that taxes are expressed as percentage of GDP, hence, taxes are not restricted in nominal terms.
(2) Price deflators are not impacted by factor shares and productivity immediately, considering deflators are largely set by exogenous elements not defined in the system.
(3) Profitability is not impacted by labour share immediately. The assumption is that when labour contribution changes, due to hiring or higher wage dynamics, it does not impact the output and profitability right away. Granger causality test results showed that labour share has a relatively limited impact on profitability, compared to the other way around. Still, considering that interactions between factor ratios are key assumptions of this paper, several robustness checks have been made to challenge this and other assumptions, as well (see: next section below).
(4) Capital and labour ratios are not impacted by productivity immediately, only with one quarter delay. Considering that capital and labour decision takes time and national accounts data are available with a lag (around +45 days), it is assumed that productivity does not impact the variable paths immediately.

To put it differently, zero restrictions were applied, and matrix A – representing contemporaneous relationship – is a lower triangular matrix, assuming the following ordering of variables: taxes on capital, taxes on labour, price deflator, capital contribution, labour contribution and productivity. It is assumed that the variables at the beginning of this order are

[8] Capital tax can have an immediate impact on labour tax in order to take into account potential impacts from capital related channels on labour channels.

more exogenous than the subsequent variables. These restrictions are sufficient to identify the structural model.

Robustness

For robustness checks, additional SVAR models were constructed – mostly – by excluding all endogenous variables except factor ratios, and also by imposing alternative restrictions:

Model 2, large-scale VAR (M 2 baseline): in this model the profitability assumption (3) was inverted ceteris paribus (labour share is not impacted by profitability immediately).

Model 3, small-scaled VAR (M 3 baseline): this model uses eight lags based on information criteria and restriction (3) from above to identify the structural model (profitability is not impacted by labour share immediately). Only two endogenous variables (profit and labour growth contributions) were incorporated.

Model 4, small-scaled VAR (M 4 baseline): it uses eight lags based on information criteria and restriction (3) was inverted (i.e. labour share is not impacted by profitability immediately). Only two endogenous variables were incorporated (profit and labour growth contributions).

For both small-scaled VAR models additional robustness checks were run to control for various sources of heterogeneity and potential specification errors:

- *Lag structure (4 and 12 lags)*: models were estimated based on 4 and 12 lags instead of 8.
- *Time stability (First and second subsample)*: the sample was divided into pre- and post-crisis periods (before and after 2010) to investigate heterogeneity in time.
- *Developed vs less developed countries (non-EUR)*: the models were re-estimated using data of non-eurozone EU member states. The rationale is that eurozone economies are highly developed and the weight of eurozone is very high within the union (~80-90%). Therefore, by focusing on the remaining, typically less developed economies, the baseline results can be effectively challenged.
- *Definition of wages (wages)*: the models were re-estimated using wages and salaries, instead of using compensation of employees to check the robustness of the salary definition – the difference is that compensation also includes employers' social contributions. It can be argued that social contributions are associated with fiscal policy, hence, replacing the dependent variable might be intuitive.
- *Definition of profit (profit)*: the models were re-estimated based on profit of the non-financial corporation sector instead of total economy to check the robustness of the profit definition. This adjusted profit contributes to ~50% of the total gross operating surplus and mixed income. It can be argued that the profit definition of the non-financial sector is the closest to real profitability.

- *Cross sectional and periodic heterogeneity (panel)*: the models were re-estimated using all the individual country (panel) data with fixed effects.

The small-scaled VARs have the following unrestricted form:

$$(Y_t) = b_1 \cdot (Y_{t-1}) + b_2 \cdot (Y_{t-2}) + b_3 \cdot (Y_{t-3}) + b_4 \cdot (Y_{t-4}) + b_5 \cdot (Y_{t-5}) + b_6 \cdot (Y_{t-6}) + b_7 \cdot (Y_{t-7}) + b_8 \cdot (Y_{t-8}) + c \quad (8)$$

where: Y = capital and labour growth contribution in log terms, c = exogenous variables (constant, seasonal dummies and deterministic trend).

3.5 Empirical Results of SVAR Estimations

Summarized results of the VAR estimations are shown in Tables 3-5 in the Appendix. Table 3 shows R^2 of each equation: a high fraction of variation can be explained (typically above 70%). Table 4 shows the residual diagnostics of autocorrelation for lags 1-8: residuals seem to be white noises at standard significance levels. Figure 2 shows baseline results, while Figure 3-5 in the Appendix illustrate all impulse response functions of a capital income shock, i.e. the lagged adjustment and further impacts on the other variables.

Labour ratio pattern is inline with expectations. Labour income increases slightly and somewhat gradually after the profit growth and reaches its maximum typically in the second quarter. Therefore, VARs confirm that there is positive lagged adjustment: profitability influences labour income with some lag, i.e. there is a discrepancy in the short run.

The maximum labour impact of a one-standard deviation profit shock is a ~0.003-0.006 log-scale response in absolute terms and ~0.01-0.03 accumulated in 10 quarters after the shock. These correspond to a ~0.4% individual and to a ~2% accumulated labour increase, which can be considered as moderate responses. Note that results reflect both the normalization of the variables, as well as the scaling of the structural shock (to a one-standard deviation innovation).

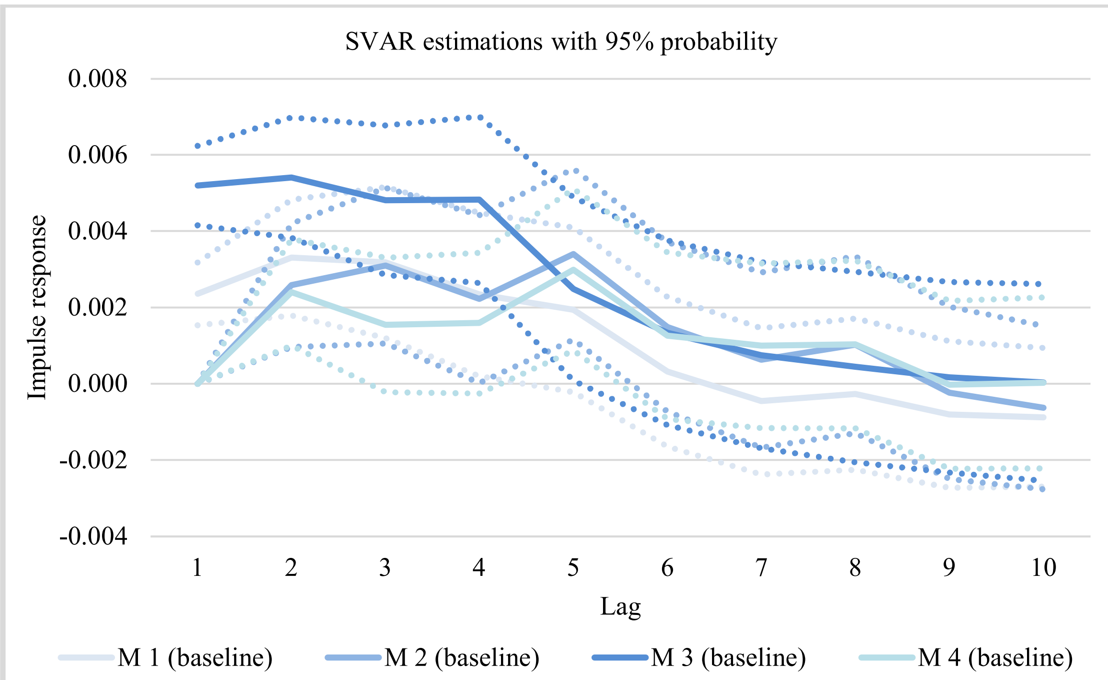
The accumulated impacts could be material enough under certain scenarios, for instance when the profit shock is strong enough, i.e. in a recession or in a recovery period. Moreover, the impacts of the shock on factor ratios are comparable: the profit impact on labour is ~50% lower compared to the profit shock on profit outlook.

One way to interpret these results is to argue that labour income related rigidities are relatively strong in the EU-27 and the rigidities limit the impacts of various shocks, including profit shocks. Small-scaled SVARs show similar results as the large-scale models but some of them show the highest impact in lag 5.

The results are in general robust to various sources of heterogeneity (cross sectional and period heterogeneity, definition of variables, lag structure). Some of the benchmark models show stronger results, for instance when we incorporate non-euro member states only. This seems to be intuitive, considering that wage rigidities could be stronger in the eurozone, driven by institutions, leading to higher impacts in non-euro member states. The impacts are also relatively stronger (and shocks on both ratios are more comparable) when we use the profit data of the non-financial sector only. This is also inline with expectations and suggests that the impact is stronger once the profit definition is closer to the real profit (i.e. we ignore public sector data for instance).

There is also evidence that in some cases the impacts are lower, in particular when we control for cross sectional (country specific) and time heterogeneity. Note, however, that there is still evidence for lagged adjustments in the panel models.

Figure 2: SVAR Impulse responses of a 1 standard deviation capital shock on labour: baseline models



Note: The graphs show impulse responses of a 1 standard deviation profit shock on labour income in 10 consecutive quarters, under various scenarios. M 1-4 stand for the various VAR baseline model estimations, presented in section 3.4. Dotted lines show the confidence intervals with 95% probability.

In reality we would not expect that the lagged response lasts long, because companies typically react relatively quickly to the changes of profitability. Based on the recent periods (i.e. after 2010) the delay seems to be shorter according to the SVAR estimations. Note that companies primary influence the volume of labour and not the real wage level as the latter is determined by labour supply and demand interactions (especially by the tightness of the labour market).

The structural capital shock also impacts consecutive capital income persistently. The profit shock also generates more capital tax revenue to the government but only in the very short run based on Model 1, while we see some positive impacts on the labour taxes with a delay. In general, positive impacts are expected for the fiscal variables, which is not always the case. One reason of this could be that not all of the relevant tax drivers are available for the production factors on a quarterly basis.

The prices first go up and then sharply go down. The first impact might reflect the fact that the increase of profitability could be a follow up of rising aggregate demand causing a price increase. The second effect might be a result of increasing capital supply leading to lower prices.

Higher profitability typically leads to lower variance of productivity, which might be somewhat surprising as it means that a profit increase is followed by stronger convergence in terms of productivity. This could be driven by stronger growth performance – in terms of capital and productivity – of recently joined members states, which leads to stronger catching up.

4 Summary and Conclusions

In this paper the stability of capital-to-income and labour-to-income ratios in the EU-27 was reviewed. Several factors can lead to time-varying output elasticities, these were presented and discussed in the first two sections. In the third section a lagged adjustment was tested and estimated, which is a specific reason for time dependent factor shares introduced in this paper. It is expected that the change of profitability influences labour decisions, but this response is not immediate, there are both internal and external reasons for lagged adjustment.

Formal tests confirm that profitability Granger causes labour ratio, which is typically one-sided, hence, profitability contains sufficient information to predict the labour ratio. The lagged adjustment is estimated based on SVAR models: a short-run discrepancy is confirmed and the impacts are moderate. Models were estimated based on national accounts data, while micro data are usually taken into account in practice. Within this paper, we identify several grounds for adopting national accounts data.

One way to interpret these results is to argue that labour income related rigidities are relatively strong in the EU-27, driven by various factors such as strong employment protection legislation and centralized wage-bargaining systems. Hence, wage rigidities could mitigate the impact of profit shocks and could also dampen the impacts in a recession period, leading to a lagged adjustment.

The results also imply that incorporating lagged adjustments could potentially improve modeling results. For instance, incorporating a lagged response coming from a material profit shock could improve the backtesting power of GDP nowcasting models. Incorporating a lagged adjustment of labour similarly to habit formations in DSGE models could also bridge some gap between empirical results and theoretical foundations. Broadly speaking, incorporating endogenous elasticities of output in macroeconomic models could improve modeling results in general.

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Appendix 1

Output elasticities are often estimated from micro data but estimations can be biased due to several reasons. In the lack of accrual and other national account adjustments, these data may not always correspond to actual economic transactions and they might be subject to measurement error. This means that micro data may represent cash payments and not economic transactions (e.g. they may represent last year's transactions instead of the current one). Also, the output of the government and the financial corporations sector may be missing from micro data.

It is also important to note that there are many transaction reclassifications in national accounts between and within sectors, so the recording of activities between standard accounting and national accounting can vary; national accounts probably have better data quality. For example, in standard accounting, a national railway company records its transactions including labour data in the private sector. However, when this company is owned by the central government and certain requirements are met, this record is reclassified into transactions of the general government sector in national accounts. At an aggregated level it should not matter which transaction is generated by which sector, but the performance of public activities is usually measured in a different way (usually based on costs generated), as these are non-market transactions. For further information see: Eurostat (2013).

In the ESA framework, capital share is approximated by gross operation surplus, which is similar to the standard, financial operating surplus. Two major differences exist: the net operating surplus (i.e. gross surplus minus consumption of fixed capital) of traditional public institutions is zero by definition and in many cases this surplus is measured as a residual item calculated mainly from the difference of gross value added and labour force data (compensation of employees). So these data also contain some further company costs and might be subject to endogeneity bias, as well as statistical discrepancy. It also means that capital income not only incorporates standard capital accumulation through net investments, but also other transactions leading to changes in the capital income. Hence, capital income stands rather for raw profits than for net investments only. Other important differences are reviewed by Lequiller and Blades (2014).

The labour income is also interpreted somewhat differently than in practice. Compensation of employees includes gross wages and salaries as well as the employers' social contributions. Similarly to other national account items, these are recorded based on accrual adjustment. For example, let's say an employee receives his/her salary in November based on his/her performance delivered October. In national accounts this transaction is recorded in October.

One major difference between the theoretical and data framework is that technological progress is not defined in national accounts. In macroeconomics, Total Factor Productivity (TFP) is usually labour augmented (which is called Harrod neutral progress after Harrod, 1939) in order to have balanced and constant, stable steady state growth (Uzawa, 1961). TFP is modelled typically the following way in the Cobb-Douglas case:

$$Y = TK^{\alpha}L^{1-\alpha} = K^{\alpha}(AL)^{1-\alpha} = f(A, K, L), \text{ where } A = T^{1/(1-\alpha)},\ 0 < \alpha < 1 \qquad (9)$$

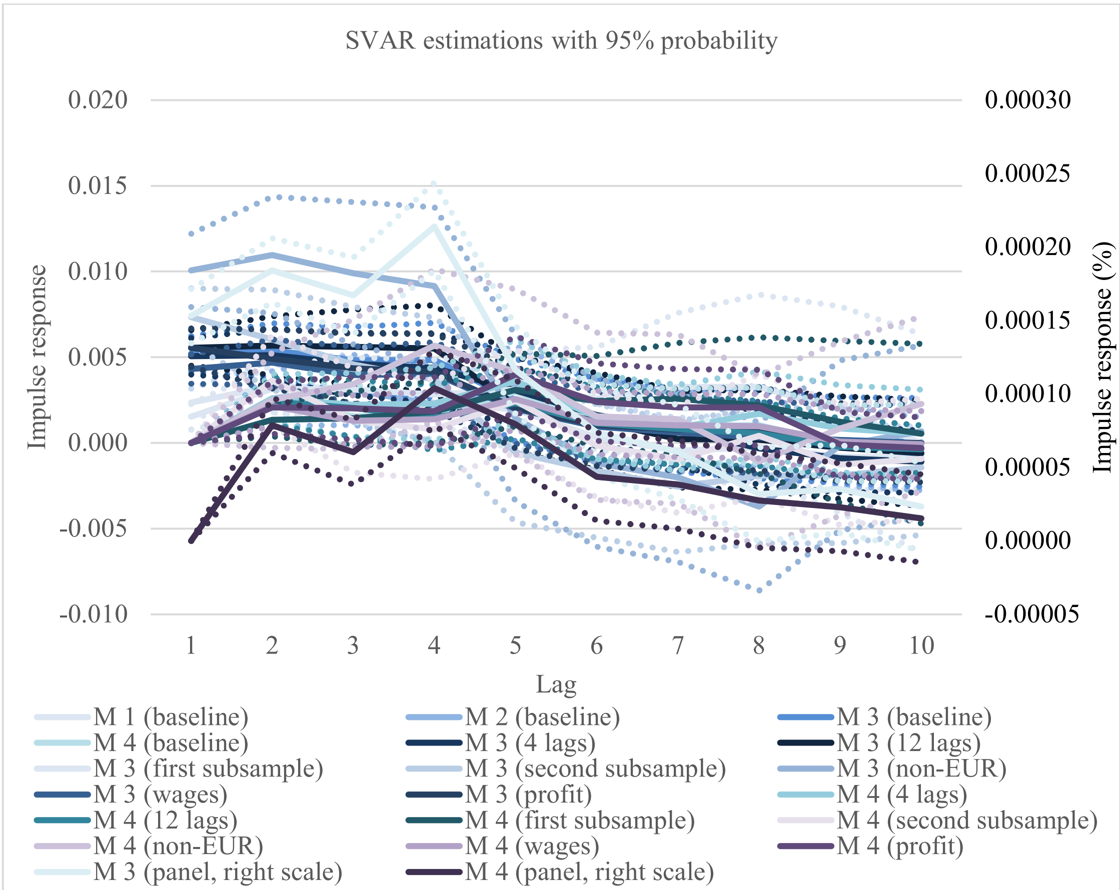
It can be argued that the observed labour income partially reflects the technological progress, e.g. some employees get a salary increase as a reward for a more efficient performance (beyond working hours), which is recorded as a surplus in labour costs. Theoretically, T can also be capital augmented[9], as well. It can be argued in this case the same way: capital income may include a profit increase driven by productivity increase.

It is important to point out that production functions are usually constructed to estimate potential GDP. When T is labour augmented, the estimation of capital share from national accounts data might be still unbiased. The reason for that is though there is an omitted variable (technology), we might assume that it is not correlated with capital. To put it differently, the estimation of α could be biased when the technology is not labour augmented under the Cobb-Douglas framework and the technology correlates with the capital.

[9] When the steady state exists, capital augmented technological progress can be approximated by labour augmented technological change. (Barro – Sala-i-Martin, 2004)

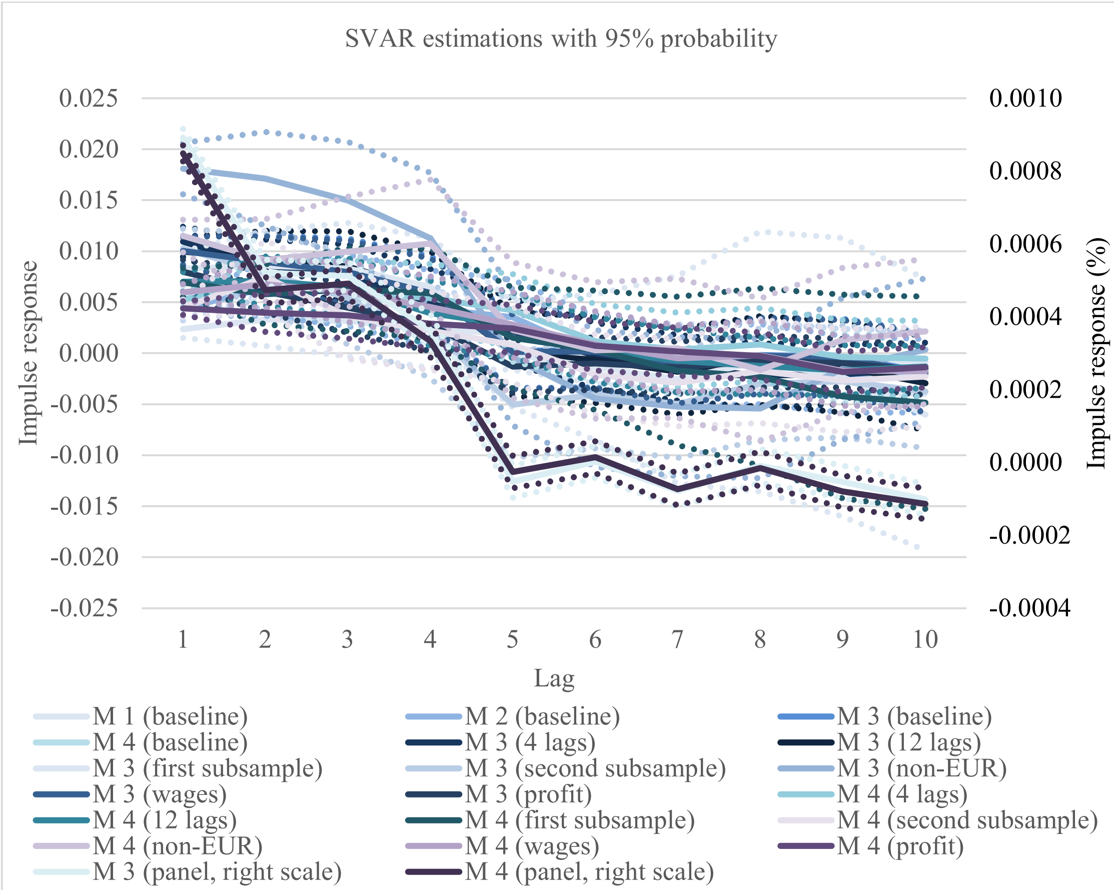
Appendix 2

Figure 3: SVAR Impulse responses of a 1 standard deviation capital shock on labour: all models



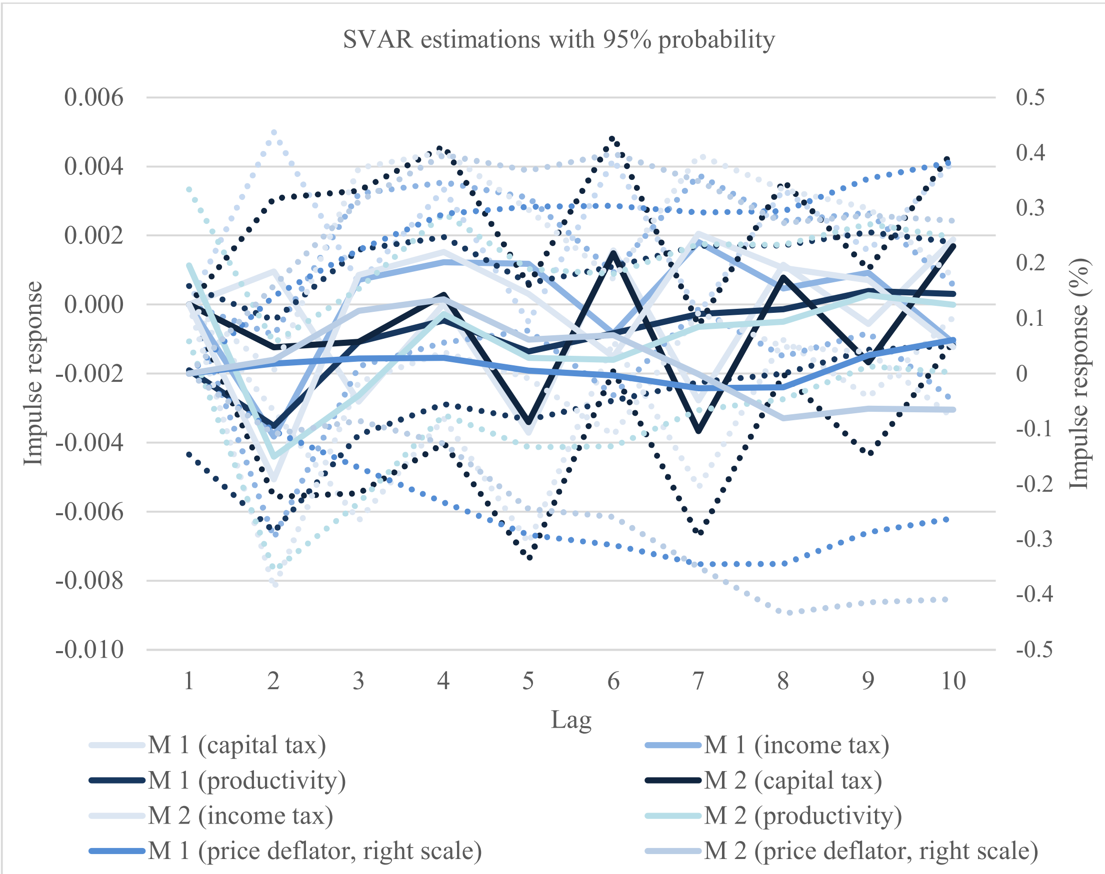
Note: The graphs show impulse responses of a 1 standard deviation profit shock on labour income in 10 consecutive quarters, under various scenarios. M 1-4 stand for the various VAR estimations, baseline and alternate candidate models are presented in section 3.4. The following robustness checks are illustrated: various lag structure (4 and 12 lags), different time horizon (first and second subsample), using non-euro country data only (non-EUR), changing variable definitions (wages, profit) and fixed effects panel data modeling (panel). Dotted lines show the confidence intervals with 95% probability.

Figure 4: SVAR Impulse responses of a 1 standard deviation capital shock on profit outlook: all models



Note: The graphs show impulse responses of a 1 standard deviation profit shock on capital income in 10 consecutive quarters, under various scenarios. M 1-4 stand for the various VAR estimations, baseline and alternate candidate models are presented in section 3.4. The following robustness checks are illustrated: various lag structure (4 and 12 lags), different time horizon (first and second subsample), using non-euro country data only (non-EUR), changing variable definitions (wages, profit) and fixed effects panel data modeling (panel). Dotted lines show the confidence intervals with 95% probability.

Figure 5: SVAR Impulse responses of a 1 standard deviation capital shock on rest of the variables: all models



Note: The graphs show impulse responses of a 1 standard deviation profit shock on the rest of the variables (i.e. excluding labour and capital) in 10 consecutive quarters, under various scenarios. M 1-2 stand for the various VAR baseline model estimations presented in section 3.4. Dotted lines show the confidence intervals with 95% probability.

Appendix 3: baseline model diagnostics

Table 2: Unit root test results (p-values)

Variables	ADF	PP
TAX_CAP(log difference)	0.1171	0.0000
TAX_INC (log difference)	0.0072	0.0001
GDPDEFL_CPI	0.0010	0.3081
CAPITAL_GC_EU (log)	0.0116	0.0512
LABOUR_GC_EU (log)	0.1062	0.0165
PROD (log difference)	0.1507	0.0000

Table 3: VAR diagnostics: Adjusted R^2

	TAX_CAP (log difference)	TAX_INC (log difference)	GDPDEFL_CPI	CAPITAL_GC_EU (log)	LABOUR_GC_EU (log)	PROD (log difference)
Model 1 and 2	0.60	0.84	0.96	0.67	0.70	0.88
Model 3 and 4	NA	NA	NA	0.64	0.66	NA

Table 4: VAR diagnostics: Residual autocorrelation

Lags	Model 1 and 2		Model 3 and 4	
	LM-Statistics	Probability	LM-Statistics	Probability
1	43.38	0.19	3.49	0.48
2	42.86	0.20	6.46	0.17
3	37.52	0.40	5.97	0.20
4	28.75	0.80	8.32	0.08
5	33.65	0.58	5.96	0.20
6	23.59	0.94	6.12	0.19
7	31.20	0.70	5.79	0.22
8	38.12	0.37	6.41	0.17

Table 5: SVAR restrictions: estimated A-B matrixes

Model 1:

Estimated A matrix:					
1.00	0.00	0.00	0.00	0.00	0.00
-0.13	1.00	0.00	0.00	0.00	0.00
-5.74	-6.99	1.00	0.00	0.00	0.00
-0.09	0.73	0.00	1.00	0.00	0.00
0.03	0.07	0.00	-0.44	1.00	0.00
0.19	-0.21	0.00	-0.26	1.40	1.00
Estimated B matrix:					
0.02	0.00	0.00	0.00	0.00	0.00
0.00	0.01	0.00	0.00	0.00	0.00
0.00	0.00	0.54	0.00	0.00	0.00
0.00	0.00	0.00	0.01	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.01

Model *2:*

Estimated A matrix:					
1.00	0.00	0.00	0.00	0.00	0.00
-0.13	1.00	0.00	0.00	0.00	0.00
-5.74	-6.99	1.00	0.00	0.00	0.00
-0.01	0.39	0.00	1.00	0.00	0.00
-0.08	0.43	0.00	-0.77	1.00	0.00
0.19	-0.21	0.00	1.40	-0.26	1.00
Estimated B matrix:					
0.02	0.00	0.00	0.00	0.00	0.00
0.00	0.01	0.00	0.00	0.00	0.00
0.00	0.00	0.54	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.01

Model 3:

Estimated A matrix:	
1.00	0.00
-0.51	1.00
Estimated B matrix:	
0.01	0.00
0.00	0.00

Model 4:

Estimated A matrix:	
1.00	0.00
-1.27	1.00
Estimated B matrix:	
0.01	0.00
0.00	0.01