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Distribution, aggregate demand and productivity growth – theory and empirical results for six OECD countries based on a Post-Kaleckian model[#]

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Abstract

Empirical research based on the Bhaduri/Marglin-variant of the Kaleckian model has recently shown that aggregate demand in many medium-sized and large open economies tends to be wage-led in the medium to long run, even in a period of increasing globalisation. In this paper we extend this type of analysis and integrate the effects on productivity growth, theoretically and empirically. Productivity growth is introduced into the theoretical model making use of the Verdoorn effect or of Kaldor's technical progress function and hence of a positive relationship between GDP or capital stock growth and productivity growth. Further on, a cost-push or Marx/Hicks-effect and hence a positive impact of real wage growth or the wage share on productivity growth is taken into account. In the empirical part we estimate productivity growth equations for six countries introducing these two effects. Finally, economic policy conclusions are drawn.

JEL code: E12, E21, E22, E25, O41

Keywords: Demand-led growth, endogenous technical change, wage-led and profit-led demand regimes, productivity regime

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1. Introduction

The recent two and a half decades have seen remarkable changes in functional income distribution, in particular in Continental European countries (see Table 1). Whereas the labour income share had a slight tendency to increase until the recession of the early 1980s it has shown a remarkable downward trend since then. The USA have seen similar but not so pronounced developments, whereas in the UK functional income distribution has changed even less over the last five decades. These developments beg the question as to their causes and in particular their effects regarding capital accumulation, GDP growth and productivity growth. Supply-driven old and new growth models would expect redistribution in favour of profits to cause increasing saving and investment, and hence increasing productivity growth and long-run GDP growth (Grossman/Helpman 1994, Kurz/Salvadori 2003, Romer 1994, Solow 2000). The implications of Post-Keynesian demand driven model, however, are less clear cut.

In the Kaldor-Robinson model, in which firms' investment decisions, determined by animal spirits and expected profits, affect growth and income distribution, an inverse relationship between the wage share, on the one hand, and capital accumulation, GDP and productivity growth, on the other hand, would be expected, due to the assumption of long-run full or 'normal' utilisation of productive capacities given by the capital stock.[1] The causality compared to new growth models, however, runs in the opposite direction: Distribution is rather affected by investment and saving decisions. Kaleckian distribution and growth models, with a variable rate of capacity utilisation in the long run and income distribution being mainly determined by mark-up pricing in incompletely competitive goods markets, may yield different results, depending on the specification of the investment function of the model.[2] In the 'stagnationist' variant of the Kaleckian model, pioneered by Rowthorn (1981), Dutt (1984, 1987, 1990) and Amadeo (1986a, 1986b, 1987), a rising wage share has expansive effects on the equilibrium rates of capacity utilisation, profit and capital accumulation (and also on productivity growth, according to Rowthorn (1981) and Dutt (2003)) due to a strong accelerator effect in the investment function. Bhaduri/Marglin (1990), however, in a Kaleckian model without productivity growth have shown that the inclusion of unit labour cost effects into the investment function allows for different regimes: Depending on the

[1] See Kaldor (1955/56, 1957, 1961), Robinson (1956, 1962) and the surveys in Lavoie (1992: 284-296) and Hein (2004: 149-176).

[2] See Kalecki (1954, 1971), Steindl (1952) and the surveys in Lavoie (1992: 297-347), Blecker (2002) and Hein (2004: 177-219).

parameter values in the saving and investment function, profit- or wage-led demand and growth regimes may emerge. Therefore, starting with the work by Bowles/Boyer (1995), Bhaduri/Marglin's (1990) theoretical conclusion has increasingly inspired empirical research on the relationship between functional income distribution and aggregate demand, respectively growth.[3]

However, the Kaleckian models, as well as the empirical estimations based on the Bhaduri/Marglin (1990) model, have only occasionally taken productivity growth into account. Rowthorn (1981), Taylor (1991: 225-228), You (1994), Cassetti (2003) and Dutt (2003) have introduced endogenous productivity growth into different variants of the Kaleckian model. And Naastepad (2006) has included productivity issues into her estimations for the Netherlands based on the Bhaduri/Marglin model, albeit in an incomplete way: There is no effect of productivity growth on investment in her model, and real wage growth instead of distribution is taken to be the exogenous variable. This implies that in her model with exogenous real wage rate growth, productivity growth only feeds back on output growth through its effects on the profit share.[4]

Our paper builds on the recent theoretical and empirical literature on productivity growth in Kaleckian models. We attempt to integrate productivity growth into the Bhaduri/Marglin (1990) model in a consistent and systematic way. In our theoretical and empirical analysis, the profit share will be considered to be the exogenous variable and aggregate demand, capital accumulation and productivity growth will be determined endogenously. Following Setterfield/Cornwall (2002) and also Naastepad (2006), we will distinguish between the demand regime and the productivity regime in our model. We will discuss the separate effects of changes in the profit share on each of these regimes, and finally we will analyse the overall effects of changes in distribution on aggregate demand, capital accumulation and productivity growth. The model presented below will therefore be a partial model of a private open economy. It should also be noted that we do not claim to deliver a full theory of technical progress but rather limit ourselves to the analysis of the relationship between distribution, aggregate demand and productivity growth.[5] Nonetheless, extending the recent work in the Kaleckian tradition, we do not only touch the short- to medium-run

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[3] See Hein/Vogel (2008) for an overview.

[4] As will be argued in more detail below, we also hold that introducing the wage share (or the profit share) as cost push factor into the productivity function is more plausible than to use real wage growth as Naastepad (2006) does.

[5] This would require a more detailed analysis of structural change within an economy, of productivity catching up-processes among economies, as well as productivity growth conducive institutions. See for instance the studies by Cornwall/Cornwall (2002) and Vergeer/Kleinknecht (2007).

demand effects of a falling wage share, but we hope to contribute to an understanding of the long-run effects on capital accumulation, productivity growth, and hence on the potential or the ‘natural rate of growth’.

Since a lot of empirical work has already been done on the demand regimes in developed OECD countries, our empirical analysis will focus on the productivity regime. We will estimate different productivity equations, in particular an equation which is derived straight forward from the theoretical model. Using the country sample Hein/Vogel (2008) have used in their estimations of demand regimes, this paper can be seen as an extension of that study. The estimations of the productivity regime will be done for the USA as large, rather closed economy, Germany, France and the UK as medium-sized and increasingly open economies, and Austria and the Netherlands as small open economies.

The remainder of this paper is organised as follows. In Section 2 we briefly review some stylised facts on GDP growth, productivity growth and distribution for the six countries in our data set. Section 3 will continue with a simple theoretical model for a private open economy with technical progress in which we distinguish between the demand and the productivity regime, analyse the effects of a change in the profit share on each of the regimes, and finally on the overall regime. Section 4 is dedicated to a brief review of recent empirical studies on the demand regime in the six countries under investigation and a review of recent estimations of productivity equations in the literature. In Section 5 we will present the estimation results for our productivity equations which allow us to draw some conclusions regarding the productivity regime. Section 6 derives some conclusions regarding the overall regime in the six countries under investigation and draws some brief economic policy conclusions.

2. Some stylised facts on GDP growth, productivity growth and distribution

Taking a look at the development of average values over the business cycle since the early 1960s until the present, some remarkable parallels between GDP growth and labour productivity growth become obvious, in particular in the Continental European countries (Austria, France, Germany, the Netherlands) (Table 1). The break in the long-run development of GDP in the mid 1970s, from the high growth rates of the ‘golden age’ to mediocre growth trend in the ‘post-golden-age’ is accompanied by a similar break in productivity growth rates, which have shown remarkably lower values since the second cycle of the 1970s than before. Also real wage growth has dropped significantly in the Continental European countries since the mid 1970s, and since the early 1980s the labour income share has shown a continuously falling trend.[6]

The development in the USA and the UK deviates from this almost uniform pattern in the Continental European countries. These two countries also witnessed a drop in GDP and productivity growth during the cycle of the second half of the 1970s. However, already in the 1980s GDP growth and also productivity growth have started to recover and have almost reached the growth rates of the early 1970s again. For real wage growth which also dropped in the mid 1970s, in the USA it took until the 1990s to recover, whereas in the UK the recovery already started in the 1980s. The fall of the labour income share since the mid 1970s (USA) or early 1980s (UK) was therefore less marked than in the Continental European countries.

From these broad developments, the general picture emerges that GDP and productivity growth rates display a close positive relationship. Real wage growth and productivity growth also seem to be positively related, whereas there seems to exist a negative relationship between the profit share and productivity growth, in particular in the Continental European countries since the early 1980s.

[6] Note that in Table 5 labour productivity growth is for full-time equivalents, and hence reflects hourly productivity growth, whereas growth of real compensation per employees is not for full-time equivalents. Since working hours per employee have changed over time, growth of real compensation per employee falling short of (exceeding) labour productivity growth is not necessarily accompanied by a falling (rising) labour income share.

Table 1: GDP growth, productivity growth, real wage growth and labour income share on average over the business cycle in Austria, France, Germany, the Netherlands, the UK and the USA, 1960 – 2007, in percent				
	Growth of real GDP[c)]	**Growth of real labour productivity[d)]**	**Growth of real compensation per employee**	**Labour income share[e)]**
Austria				
1961-1967 [a)]	4.18	4.61	5.06	80.65
1968-1975	4.69	4.29	4.88	79.77
1976-1984	2.35	2.43	1.46	80.01
1985-1993	2.68	2.18	2.29	74.88
1994-2002	2.32	1.89	0.62	69.62
2003-2007 [a)]	2.43	1.50	0.46	63.40
France				
1961-1968 [a)]	5.37	4.92	5.32	73.35
1969-1975	4.29	3.49	4.39	72.50
1976-1981	2.82	2.46	2.21	75.96
1982-1993	2.04	2.02	1.01	70.73
1994-2003	2.23	1.26	1.19	66.64
2004-2007 [a)]	2.02	1.47	1.48	66.19
Germany [b)]				
1961-1967 [a)]	3.78	3.93	4.72	68.25
1968-1975	3.74	3.54	5.36	69.20
1976-1982	2.41	1.87	1.13	70.28
1983-1993 [d)]	2.70	1.80	1.35	66.83
1994-2003	1.56	2.11	1.44	65.79
2004-2007 [a)]	1.54	1.64	-0.21	63.23
The Netherlands				
1961-1966 [a)]	4.47	3.06	6.03	67.29
1967-1975	4.44	4.15	6.04	72.58
1976-1982	1.58	1.70	0.78	74.93
1983-1993	2.72	1.53	0.53	68.78
1994-2002	3.14	1.40	0.90	66.87
2003-2007 [a)]	1.96	1.71	0.85	65.95
UK				
1961-1966 [a)]	2.87	1.97	2.40	72.87
1967-1974	2.77	2.87	3.56	74.20
1975-1980	1.36	1.20	1.73	75.20
1981-1991	2.27	1.90	2.06	74.31
1992-2002	2.74	2.09	1.62	72.93
2003-2007 [a)]	2.76	1.91	2.35	72.76
USA				
1961-1970	4.22	2.30	2.67	69.89
1971-1974	3.54	1.54	1.50	70.83
1975-1982	2.32	0.84	0.88	69.54
1983-1991	3.47	1.44	0.76	68.41
1992-2001	3.40	1.63	1.54	67.46
2002-2007 [a)]	2.63	1.94	1.66	66.49

Notes: The local minimum of real GDP growth defines the end year of a business cycle
[a)] incomplete cycle, [b)] until 1991 only West-Germany, from 1991 onwards unified Germany, [c)] at 2000 market prices, [d)] real GDP per person employed (equal to full-time equivalents), [e)] compensation per employee as percentage of GDP at factor cost per person employed

Source: European Commission (2007), authors' calculations

3. The theoretical model

The theoretical model is based on the open economy Kaleckian distribution and growth models by Bhaduri/Marglin (1990) and Blecker (1989). Since in these models there is no technical change and hence no productivity growth, we will introduce technical change in three steps. In the first step, for the discussion of the demand regime, i.e. the effects of changes in functional income distribution on the goods market equilibrium, we assume productivity growth to be exogenous.[7] In the second step, we will then deal with the productivity regime, and technical progress will be endogenised, i.e. we will integrate the effects of changes in income distribution on productivity growth. In the third step, demand and productivity regimes will be integrated and we will discuss the effects of changes in income distribution on the overall regime. In the model, functional income distribution is considered to be the exogenous variable, determined by institutional factors and relative powers of capital and labour, i.e. by competition between firms in the goods market and between firms and labourers in the labour market. The goods market equilibrium rates of capacity utilisation, profit and capital accumulation together with the rate of productivity growth are endogenously determined. Potential feedbacks from goods market activity and productivity growth to income distribution are excluded from the analysis.[8]

In order to simplify the following discussion we assume that technical progress is labour saving and capital embodied. Technical progress is hence associated with a falling labour-output-ratio ($l = L/Y$) and rising labour productivity ($y = Y/L$). The capital-labour-ratio ($k = K/L$) increases at the same rate as labour productivity does, and the capital-potential output-ratio ($v = K/Y^p$), therefore remains constant. This means we assume Harrod-neutral technical progress.

We deal with an open economy without economic activity of the state, which depends on imported inputs for production purposes and the output of which competes in international markets. We take the prices of imported inputs and of the competing foreign final output to be exogenously given and to be moving in step. The nominal exchange rate, the price of a unit of domestic currency in foreign currency, is determined by monetary policies and international financial markets, and is also considered to be exogenous for our purposes.

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[7] On the distinction between demand and productivity regimes see Setterfield/Cornwall (2002) and Naastepad (2006).

[8] See Bhaduri (2006) on a model with endogenous productivity and real wage growth, and hence with endogenously determined functional income distribution.

3.1 The demand regime

In order to analyse the effects of changes in distribution on economic activity and capital accumulation, we start with the goods market equilibrium condition for an open economy without economic activity of the state in real terms: Planned saving (S) has to be equal to net investment (I) plus net exports (NX), the difference between exports (X) and imports (M) of goods and services:

$$S = I + (Ex - Im). \tag{1}$$

For convenience, equation (1) is normalised by the real capital stock (K). Therefore, we get the following goods market equilibrium relationship between the saving rate (σ = S/K), the accumulation rate (g = I/K) and the net export rate (b = NX/K):

$$\sigma = g + b. \tag{2}$$

Saving consists of saving out of profits (S_Π) and saving out of wages (S_W). The propensity to save out of wages (s_W) is assumed to fall short of the propensity to save out of profits (s_Π), in particular because the latter includes retained earnings of firms. The profit share relates profits to domestic income consisting of wages and profits (h = Π/(W+Π) = Π/Y),[9] the rate of capacity utilisation is the relation of output to potential output ($u = Y/Y^p$) and the capital-potential output ratio relates the capital stock to potential output ($v = K/Y^p$). Thus, we obtain for the saving rate:

$$\sigma = \frac{S_\Pi + S_W}{K} = \frac{s_\Pi \Pi + s_W (Y - \Pi)}{K} = [s_W + (s_\Pi - s_W)h]\frac{u}{v}, \quad 0 \le s_W < s_\Pi \le 1. \tag{3}$$

Investment is modelled according to Bhaduri/Marglin (1990): Capital accumulation is a positive function of the profit rate, which can be decomposed into the profit share, the rate of capacity utilisation and the capital-potential output ratio (r = hu/v). We also include technical progress, which for the time being is assumed to be exogenous, into the investment function. Since technical progress is embodied in capital stock, it will stimulate investment. Firms have to invest in new machines and equipment in order to gain from productivity growth which is made available by new technologies. This effect on investment will be the more pronounced the more fundamental technical change is: The invention of new basic technologies will have

[9] According to Kalecki (1954: 28-41) the profit share is determined by the mark-up on unit variable costs in firms' pricing in incompletely competitive goods market and by the ratio of (imported) unit material costs to unit labour costs. The mark-up depends on the degree of competition in the goods market, the relative importance of price competition, the development of overhead costs and the power labour unions.

a stronger effect on real investment than marginal changes in technologies already in existence.[10]

Since the capital-potential output-ratio is assumed to be constant also with technical change, capital accumulation is positively affected by the profit share, indicating unit profits, the rate of capacity utilisation, indicating (expected) demand, and by productivity growth ($\hat{y}$). In order for domestic capital accumulation to be positive, the expected rate of profit has to exceed a minimum rate (r_{min}), given by the foreign rate of profit or by the rate of interest in financial markets. Both possible minimum rates are considered to be exogenous in the present model.[11]

$$g = \alpha + \beta u + \tau h + \omega \hat{y}, \qquad \alpha, \beta, \tau, \omega > 0, \quad g > 0 \text{ für } r > r_{min} . \tag{4}$$

The net export rate is positively affected by international competitiveness, provided that the Marshall-Lerner condition can be assumed to hold and the sum of the price elasticities of exports and imports exceeds unity. Under this condition, the real exchange rate (e_r) will have a positive effect on net exports. But net exports also depend on the relative developments of foreign and domestic demand. If domestic demand grows at a faster rate than foreign demand, net exports will decline, ceteris paribus. Therefore, an increase in the domestic rate of capacity utilisation will have a negative impact on net exports, ceteris paribus.

$$b = \psi e_r(h) - \phi u, \qquad \psi, \phi > 0 . \tag{5}$$

The real exchange rate, which is determined by the nominal exchange rate (e) and by the relationship between foreign prices (p_f) and domestic prices (p): $e_r = ep_f/p$, is affected by changes in the profit share, but in an ambiguous way, as has been shown in detail in Hein/Vogel (2008). Assuming that firms set prices according to a mark-up on unit variable costs, consisting of imported material costs and labour costs, a change in the profit share can either be caused by a change in the mark-up or by a change in the ratio of unit costs of imported materials to unit labour costs (z). If an increase in the profit share is caused by a rising mark-up, ceteris paribus, domestic prices will rise and the real exchange rate and hence international competitiveness will decline. But if an increasing profit share is triggered by a rising ratio of unit imported material costs to unit labour costs, ceteris paribus, the real

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[10] Dutt (2003) also discusses potential effects of technical progress on saving – new products and hence consumption possibilities may cause a reduction in the propensity to save – and on the mark-up and hence income distribution – technology leaders may increase their mark-ups and hence the profit share for the economy as a whole. We will not integrate these effects into our model.

[11] In Post-Keynesian models the long-term rate of interest in financial markets is mainly determined by the central bank's interest rate policy in the long run. It is hence an exogenous variable for income generation and growth whereas the volume of credit and the quantity of money are endogenously determined (Hein 2008: 30-55, 68-81).

exchange rate will increase and international competitiveness will improve. Nominal depreciation of the domestic currency, that is an increase in the nominal exchange rate, or falling nominal wages will increase the ratio of unit material costs to unit labour costs, and will therefore make an increasing profit share go along with improved competitiveness. Empirically, if there is any relationship between the profit share and international competitiveness, this relationship seems to be positive,[12] so that we assume in what follows:

$$e_r = e_r(h), \qquad \frac{\partial e_r}{\partial h} \geq 0\,. \tag{6}$$

Stability of the goods market equilibrium requires that saving responds more elastically towards a change in the endogenous variable, the rate of capacity utilisation, than investment and net exports do together:

$$\frac{\partial \sigma}{\partial u} - \frac{\partial g}{\partial u} - \frac{\partial b}{\partial u} > 0 \qquad \Rightarrow \qquad \left[s_W + \left(s_\Pi - s_W\right)h\right]\frac{1}{v} - \beta + \phi > 0. \tag{7}$$

We shall only consider stable goods market equilibria and the effects of changes in distribution on these equilibria. The equilibrium rates (*) of capacity utilisation and capital accumulation are given by:[13]

$$u^* = \frac{\alpha + \tau h + \omega \hat{y} + \psi e_r(h)}{\left[s_W + \left(s_\Pi - s_W\right)h\right]\frac{1}{v} - \beta + \phi}, \tag{8}$$

$$g^* = \frac{\left\{\left[s_W + \left(s_\Pi - s_W\right)h\right]\frac{1}{v} + \phi\right\}\left(\alpha + \tau h + \omega \hat{y}\right) + \beta \psi e_r(h)}{\left[s_W + \left(s_\Pi - s_W\right)h\right]\frac{1}{v} - \beta + \phi}\,. \tag{9}$$

The effect of a change in the profit share on the rates of capacity utilisation and capital accumulation can be calculated from equations (8) and (9):

$$\frac{\partial u^*}{\partial h} = \frac{\tau - \left(s_\Pi - s_W\right)\frac{u}{v} + \psi \frac{\partial e_r}{\partial h}}{\left[s_W + \left(s_\Pi - s_W\right)h\right]\frac{1}{v} - \beta + \phi}, \tag{8'}$$

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[12] See the results in Bowles/Boyer (1995), Hein/Schulten/Truger (2006), Ederer/Stockhammer (2007), Naastepad/Storm (2007), Stockhammer/Hein/Grafl (2007), Ederer (2008), Stockhammer/Ederer (2008), Hein/Vogel (2008, 2009), and Stockhammer/Onaran/Ederer (2009).

[13] The equilibrium rate of profit can easily be calculated inserting equation (8) into the definition of the profit rate: r = hu/v. However, the profit rate will not be considered explicitly in what follows.

$$\frac{\partial g^*}{\partial h} = \frac{\tau\left\{\left[s_W + (s_\Pi - s_W)h\right]\frac{1}{v} + \phi\right\} - \beta(s_\Pi - s_W)\frac{u}{v} + \beta\psi\frac{\partial e_r}{\partial h}}{\left[s_W + (s_\Pi - s_W)h\right]\frac{1}{v} - \beta + \phi}. \tag{9'}$$

Assuming the goods market equilibrium to be stable, equation (8') shows that an increasing profit share will have no unique effect on equilibrium capacity utilisation: there are positive effects via investment (τ) and net exports $[\psi(\partial e_r / \partial h)]$ but also a negative effect via consumption$[-(s_\Pi - s_W)(u/v)]$. For equilibrium capital accumulation a similar result is obtained, as can be seen in equation (9'). Again, we have positive effects via investment $[\tau\{[s_W + (s_\Pi - s_W)h](1/v) + \phi\}]$ and net exports $[\beta\psi(\partial e_r / \partial h)]$ but a negative effect via consumption $[-\beta(s_\Pi - s_W)(u/v)]$. Depending on the relative strength of each of these effects, a rising profit share may cause rising rates of capacity utilisation and capital accumulation or falling rates. In the first case, we would obtain a profit-led demand regime, in the second case demand would be wage-led. A wage-led regime becomes the more likely the lower the elasticity of investment with respect to the profit share, the lower the effect or redistribution is for international competitiveness and net exports and the higher the difference in saving propensities out of profits and out of wages.

Contrary to Bhaduri/Marglin (1990) we abstain from further differentiating the potential demand regimes with the help of equations (8') and (9'), but rather continue with the discussion of the productivity regime.[14]

3.2 The productivity regime

Within Post-Keynesian distribution and growth theory, in particular Kaldor has developed different ways to endogenise technological change. In his technical progress function (Kaldor 1957, 1961), productivity growth is positively affected by the growth of capital intensity, because technical progress is capital embodied. Another possibility has been proposed by Kaldor (1966) looking for an explanation of the (slow) growth in the United Kingdom. There he applies Verdoorn's Law.[15] According to Verdoorn (1949), the growth rate of labour productivity in industrial production is positively associated with the growth rate of output. This can be explained by static and dynamic economies of scale: The expansion of aggregate

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[14] Bhaduri/Marglin (1990) also derive an antagonistic-stagnationist regime in which a rising profit share reduces equilibrium capacity utilisation but increases equilibrium capital accumulation. As can be seen from equations (8') and (9') such a regime arises, if investment decisions are hardly affected by capacity utilisation and hence β is very small.

[15] On Verdoorns's Law see the contributions in McCombie/Pugno/Soro (2002a).

demand, sales and hence the market allows for increasing rationalisation and mechanisation and favourably affects technical progress and productivity growth.

Following these approaches implies that the growth rate of labour productivity is positively affected by the dynamics of output and/or capital stock. Therefore, we can either integrate capacity utilisation or capital accumulation into the equation determining productivity growth. Rowthorn (1981) and Dutt (2003), for example, have chosen the latter way of integration productivity growth into Kaleckian distribution and growth models.[16]

Apart from aggregate demand and output, we will consider a second determinant of productivity growth which has been taken into account in recent theoretical and empirical work on the basis of the Kaleckian model. Cassetti (2003) and Naastepad (2006), as well as already Taylor (1991: 225-228), have introduced a wage push variable into the productivity equations of their models, making use of an idea proposed by Marx (1867) and Hicks (1932).[17] The argument is as follows: Low unemployment and increasing bargaining power of employees and their labour unions will speed up the increase in nominal and real wages which will finally generate a rising wage share and hence a falling profit share.[18] This will accelerate firms' efforts to improve productivity growth in order to prevent the profit share from falling. Dutt (2006) has recently argued that increasing pressure from lower unemployment and rising real wages will accelerate the diffusion of innovations and will thus increase productivity growth.

Taking into account both determinants yields the following equations for labour productivity growth:

$$\hat{y} = \eta + \rho u - \theta h, \qquad \eta, \rho, \theta > 0, \tag{10a}$$

or:

$$\hat{y} = \eta + \varepsilon g - \theta h, \qquad \eta, \varepsilon, \theta > 0. \tag{10b}$$

In order to facilitate graphical analysis in the following section, equation (10a) contains the Verdoorn relationship between output/capacity utilisation and productivity growth, whereas equation (10b) contains the technical progress function, i.e. a positive relationship between

[16] Atesoglu/Smithin (2006) use GDP growth as a determinant of productivity in a more general demand-led macroeconomic model.

[17] See also Lima (2004) who makes use of a non-linear effect of the wage share on technological innovations in a somewhat more complex model than ours. However, in his model there is no Verdoorn effect or technical progress function. See also Lima (2000).

[18] In a Kaleckian model of an open economy, as the one presented here, nominal wage growth exceeding productivity growth will cause a rise in the wage share and a drop in the profit share, even if the mark-up on unit labour costs in firms' pricing remains constant (Hein 2005).

capital stock growth and productivity growth.[19] Productivity growth is hence positively affected by capacity utilisation or capital stock growth, and negatively by the profit share. Equation (10b) is also used by Cassetti (2003), whereas Naastepad (2006) in her empirical model for the Netherlands has chosen real wage growth, and not the profit or the wage share, as determinant of wage induced productivity growth. We follow Cassetti (2003), because we hold that real wage growth will only give an additional push to capitalists' efforts to implement technical progress, if it exceeds productivity growth and downward pressure on the profit share or on unit profits is exerted.

Different from the demand regime, a change in the profit share has a uniquely inverse effect on the productivity regime:

$$\frac{\partial \hat{y}}{\partial h} = -\theta < 0 . \tag{10a,b'}$$

Independently of capacity utilisation, capital stock growth or income distribution, productivity growth in equations (10a) or (10b) is determined by the constant which can be interpreted as representing 'learning by doing'.

3.3 Effects of a change in the profit share on the overall regime

In order to calculate the total effect of a change in the profit share on demand and productivity regime, we first have to determine the overall equilibrium with a given profit share. Graphically, we obtain this equilibrium in Figure 1a, which contains the goods market equilibrium rate of capacity utilisation from equation (8) and the productivity equation (10a),[20] and in Figure 1b, which shows the goods market equilibrium rate of capital accumulation from equation (9) and the productivity equation (10b). With an exogenous profit share ($\bar{h}$), we obtain a dynamic equilibrium in which the rate of capacity utilisation (u**), the rate capital accumulation (g**) and the growth rate of labour productivity ($\hat{y}*$) are determined endogenously.[21] The 'natural rate of growth', or potential growth, is hence endogenous in our model.

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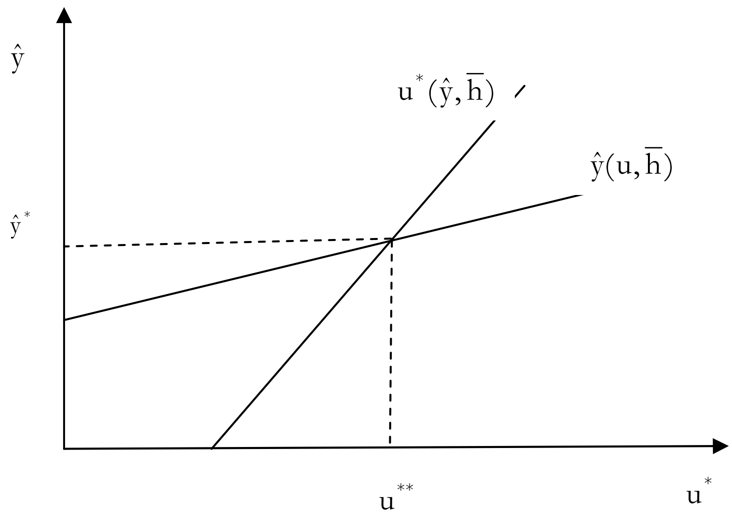
[19] Since the relationship between the goods market equilibrium rates of capacity utilisation and capital accumulation is given by equations (8) and (9), this also implies a definite relationship between the coefficients ρ and ε in equations (10a) and (10b). This is of no further importance for the following qualitative theoretical analysis.

[20] See the appendix for an analytical solution for the equilibrium and the effects of a change in distribution on the equilibrium rates of capacity utilisation and productivity growth.

[21] Also the profit rate (r = hu/v) which is not considered explicitly in this paper is determined endogenously, of course.

Figure 1: Growth equilibrium with endogenous productivity growth

a) Capacity utilisation and productivity growth



b) Capital accumulation and productivity growth

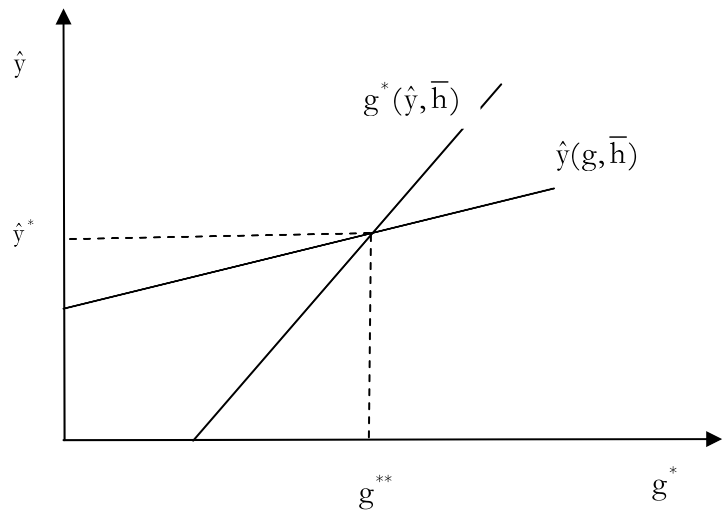


Figure 2: Increasing profit share and wage-led demand regime

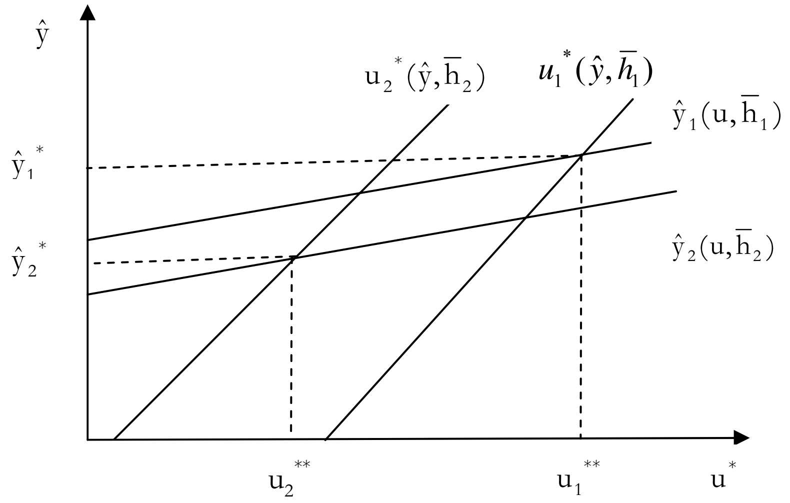
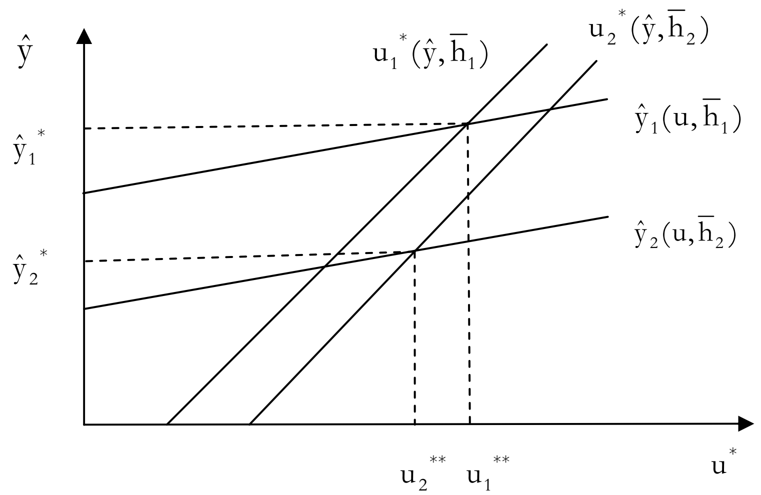
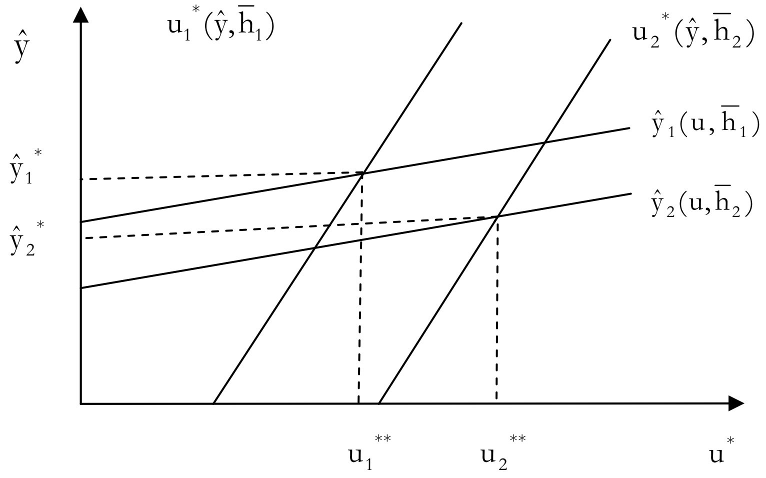


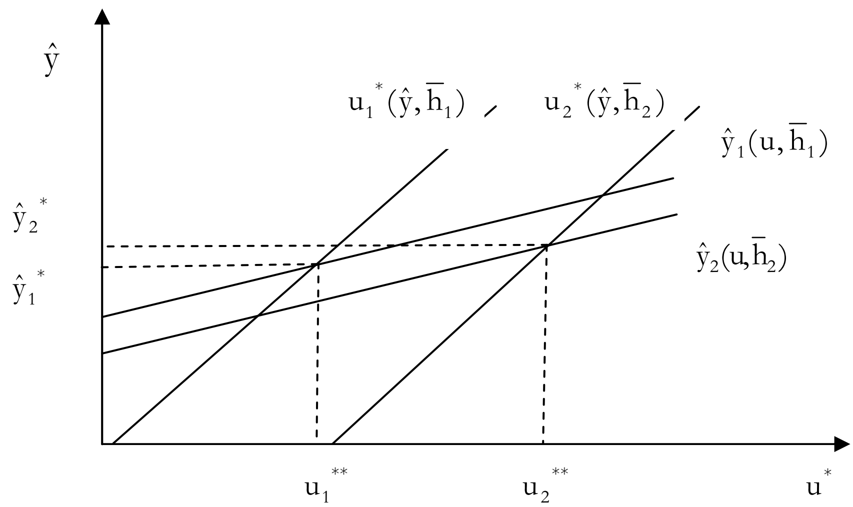
Figure 3: Increasing profit share and profit-led demand regime
a) Contractive overall regime



b) Intermediate overall regime



c) Expansive overall regime



The existence and the stability of the overall equilibrium require that the slope of the capacity utilisation equation (the capital accumulation equation) exceeds the slope of the productivity equation in Figure 1a (in Figure 1b). Therefore, from equations (8) and (10a) and Figure (1a) we obtain the following condition for the existence and stability of an overall equilibrium of capacity utilisation and productivity growth:

$$\left[s_W + (s_\Pi - s_W)h\right]\frac{1}{v} - \beta + \phi - \omega\rho > 0 \qquad (11)$$

From equations (9) and (10b) and Figure (1b) the condition for existence and stability of an overall equilibrium of capital accumulation and productivity growth is:

$$(1 - \omega\varepsilon)\left\{\left[s_W + (s_\Pi - s_W)h\right]\frac{1}{v} + \phi\right\} - \beta > 0 \qquad (12)$$

Analysing the effects of a change in distribution on the overall equilibrium we have to distinguish between wage-led and profit-led demand regimes. With a wage-led demand regime the effects of a change in the profit share on aggregate demand, respectively capital accumulation, and on productivity growth are in same direction: An increasing profit share (from $\bar{h}_1$ to $\bar{h}_2$) has partially negative effects on the demand and on the productivity regime, and these partial effects then reinforce each other. Figure 2 shows the total effect with respect to capacity utilisation (reduction from u_1^{**} to u_2^{**}) and productivity growth (decrease from $\hat{y}_1^*$ to $\hat{y}_2^*$). Since we have not further differentiated the demand regimes regarding different effects on capacity utilisation and capital accumulation, the overall effects on capital accumulation and productivity growth are qualitatively basically the same and will not be studied explicitly in what follows.

Under the conditions of a profit-led demand regime, a change in distribution has opposite effects on aggregate demand, respectively capital accumulation, and on productivity growth. The overall results of an increasing profit share will therefore depend on the relative strength of each of these effects. If the expansive effect on the demand regime is rather weak, and the contractive effect on the productivity regime is rather strong, we obtain an overall contractive effect, as shown in Figure 3a: Capacity utilisation, capital accumulation and productivity growth are reduced. However, if the positive effect on the demand regime is very pronounced and the negative effect on the productivity regime is rather weak, we obtain an expansive overall case, as can be seen in Figure 3c: The rates of capacity utilisation, capital accumulation and productivity growth increase in the face of a rising profit share. With intermediate partial effects on demand and productivity regime, an overall intermediate case is possible as well: An increasing profit share triggers higher rates of capacity utilisation and capital accumulation, but lower productivity growth rates, as is displayed in Figure 3b. Table 2 summarises the potential effects of a changing profit share on the demand, the productivity and the overall regime.

Table 2: Overall effects of a change in the profit share

	Wage-led demand regime: $(\partial u^*/\partial h)<0, (\partial g^*/\partial h)<0$	Profit-led demand regime: $(\partial u^*/\partial h)>0, (\partial g^*/\partial h)>0$		
$\partial u^{**}/\partial h$	–	–	+	+
$\partial g^{**}/\partial h$	–	–	+	+
$\partial \hat{y}^*/\partial h$	–	–	–	+
Overall regime when profit share is increasing	contractive	contractive	inter-mediate	expansive

4. Review of the empirical literature

4.1 Distribution and aggregate demand

Recently, the effects of changes in functional income distribution on aggregated demand and GDP, and hence the examination of the demand regime, have been subject of a range studies.[22] The focus of these studies has not been the short-run, cyclical effect of changes in distribution on demand and GDP but rather medium to long run effects.[23] Based on the Bhaduri/Marglin (1990) model, theses studies usually follow a method suggested by Bowles/Boyer (1995) and estimate the effects of a change in functional income distribution on aggregate demand applying a single equations estimation approach. Changes in functional income distribution are assumed to be exogenous, as in the present paper, and then the effects of these changes on consumption demand, investment demand and net exports are estimated separately. Summing up these partial effects yields the total effect of a change in income distribution on aggregate demand and GDP. Effects of technical change on aggregate demand, however, are not considered in these studies. Table 3 presents an overview of the results regarding the six countries we are interested in.

[22] For a more detailed survey of empirical results see Hein/Vogel (2008).

[23] Short-run cyclical effects have been examined for instance by Barbosa-Filho/Taylor (2006) and Stockhammer/Stehrer (2008) with mixed results.

Table 3: Demand regimes in single equations estimation studies for Austria, France, Germany, the Netherlands, the UK and the USA

	Period	Austria	France	Germany	Nether-lands	UK	USA
Bowles/ Boyer (1995)	1953/61 – 1987		profit-led	profit-led		wage-led	wage-led
Gordon (1995)	1955 – 1988						profit-led
Naastepad (2006)	1960 – 2000				wage-led		
Naastepad/ Storm (2007)	1960 – 2000		wage-led	wage-led	wage-led	wage-led	profit-led
Ederer/ Stockhammer (2007)	1960 – 2004		profit-led				
Stockhammer / Hein/ Grafl (2007)	1970 – 2005			wage-led			
Ederer (2008)	1960 – 2005				wage-led		
Hein/ Vogel (2008)	1960 – 2005	profit-led	wage-led	wage-led	profit-led	wage-led	wage-led
Stockhammer / Ederer (2008)	1960 – 2005	profit-led					
Hein/ Vogel (2009)	1960 – 2005		wage-led	wage-led			

For the period form the early 1960s to the mid 1980s, Bowles/Boyer (1995) obtain a profit-led demand regime for France, Germany and Japan, whereas the UK and the USA are wage-led in their view. Gordon (1995), however, finds the USA to be profit-led for a similar period. For the period from 1960 to 2000, Naastepad/Storm (2007) derive a wage-led demand regime for France, Germany, the Netherlands and the UK. The USA are profit-led, according to their results.[24] Naastepad (2006) and Ederer (2008) confirm the result for the Netherlands in detailed country studies. For the period from 1960 to 2005, Hein/Vogel (2008) find France, Germany, the UK, and the USA to be wage-led, whereas Austria and the Netherlands are found to be profit-led. In more detailed country studies, in particular with respect to the effects of redistribution on net exports, taking into account some features of increasing globalisation, these results are confirmed by Stockhammer/Hein/Grafl (2007) for Germany and by Stockhammer/Ederer (2008) for Austria.[25] However, France is classified to be profit-led by Ederer/Stockhammer (2007).

[24] Italy and Spain are also wage-led, according to Naastepad/Storm (2007), whereas Japan is found to be profit-led.

[25] For the Euro area, Stockhammer/Onaran/Ederer (2009) also find a wage-led demand regime for the same period.

In order to take into account interdependencies between demand aggregates, which are not included in the single equations estimation approach, Hein/Vogel (2009) started with single equation estimations and then simulated the effects of an increasing profit shares in small multi-equations models for France and Germany in the period from 1960 to 2005. Their results confirm a wage-led demand regime for France and also for Germany in the long run.

Although there remain some differences regarding the classification of single countries also in the more recent studies, in particular regarding France, the Netherlands and the USA, which may be due to differences in periods of investigation, data and estimation methods, there appears nonetheless to arise a broad common result: Whereas small open economies may be profit-led due to the dominance of the net export channel, large and medium-sized open economies still tend to be wage-led. This seems to remain true even in a period of increasing globalisation, increasing openness and increasingly integrated markets, so that redistribution in favour of profits, although it is associated with improved international competitiveness and rising net exports, will dampen the development of aggregate demand and GDP.

4.2 Aggregate demand, distribution and productivity growth

Estimations on the productivity regime can be broadly distinguished into those studies estimating the effects of aggregate demand or capital accumulation on productivity growth, those which estimate the effects of wage-push factors on productivity growth and those which include both factors, besides other control variables.

McCombie/Pugno/Soro (2002b) present a survey on more than 80 studies on the Verdoorn-effect since the original study by Verdoorn (1949) until 2001. They show that the Verdoorn-effect has been confirmed in the overwhelming majority of these studies with different methods and data. This is true for cross-section estimations for countries or regions (USA, UK, countries of the European Union, among others), or for industry branches (USA, UK, France, Germany, among others), but also for time series econometrics for single countries or regions (USA, UK, Germany, among others). Therefore, McCombie (2002) summarises the results as follows:

> „In the three decades since the publication of the inaugural lecture there have been numerous studies estimating the Verdoorn Law using a variety of different data sets. The picture that emerges is, notwithstanding the instability of the law at the level of advanced countries and with some time-series data sets, that the Verdoorn Law estimates are particularly robust with values of the Verdoorn coefficient in the range of 0.3 to 0.6 and statistically significant." (McCombie 2002: 106)

Table 4: Overview of recent empirical studies on productivity growth, demand growth and distribution which are not included in McCombie/Pugno/Soro (2002)

Author	Countries in the analysis	Period covered/ data used	Estimation method	Productivity function	Results
Verdoorn-effect only					
Schnur (1990)	Germany, total economy, manufacturing	1962-1988, Statistisches Bundesamt, IAB	OLS	$\hat{y} = f(\hat{Y}, wh, IQ)$	Total economy: $(dy/y)/(\partial Y/Y) = 0.54 \ldots 0.60$, Manufacturing industry: $(dy/y)/(\partial Y/Y) = 0.40$
Jasperneite/Allinger (1998)	West-Germany, total economy	1980-1998, OECD, IAB	OLS	$\hat{y} = f(\hat{Y})$	$(dy/y)/(dY/Y) = 0.64 \ldots 0.67$
Walterskirchen (1999)	USA, EU, Spain, Germany, UK, France, Netherlands, Austria	Cross-country: 1988-1998, time-series: 1970-1998; data source unclear	OLS time-series analysis; cross country analysis	$\hat{E} = f(\hat{Y})$	Cross-country analysis, all EU countries (1988-1998): $(dy/y)/(dY/Y) = 0.35$ Analysis by country (1970-1998): USA: $(dy/y)/(dY/Y) = 0.47$, EU: $(dy/y)/(dY/Y) = 0.59$, Spain: $(dy/y)/(dY/Y) = 0.24$, Germany: $(dy/y)/(dY/Y) = 0.54$, UK: $(dy/y)/(dY/Y) = 0.57$, France: $(dy/y)/(dY/Y) = 0.64$, Netherlands: $(dy/y)/(dY/Y) = 0.67$, Austria: $(dy/y)/(dY/Y) = 0.76$
Leon-Ledesma (2002)	18 OECD countries	1965-1994, OECD	3SLS and 2SLS	$\hat{y} = f(\hat{Y}, IQ, K, GAP)$	3SLS: $(dy/y)/(dY/Y) = 0.64$, 2SLS: $(dy/y)/(dY/Y) = 0.67$
Cornwall/Cornwall (2002)	16 OECD countries	1960-1989, OECD	Pooled regression OLS	$\hat{y} = f(\hat{Y}_c, GAP, \hat{X}, \hat{I}, U)$	$(dy/y)/(dX/X) = 0.16 \ldots 0.18$ $(dy/y)/(dI/I) = 0.08 \ldots 0.10$ $(dy/y)/(dU/U) = -0.07 \ldots -0.13$

Uni (2007)	Japan, USA, manufacturing	Japan: 1976-2003, ARNA; USA: 1978-2001, NIPA	OLS	$\hat{y} = f(\hat{Y})$	Japan: 1976-90: $(dy/y)/(dY/Y) = 0.66$, 1991-2003: $(dy/y)/(dY/Y) = 0.87$, USA: 1978-87: $(dy/y)/(dY/Y) = 0.44$, 1988-2001: $(dy/y)/(dY/Y) = 0.75$
Wage-push effect only					
Marquetti (2004)	USA	1869-1999, Dumenil/Levy (1993) extended	OLS, cointegration, Granger-causality test	$\hat{y} = f(\hat{w})$	Significant one-to-one relationship between these two; causality: $\hat{w} \rightarrow \hat{y}$
Verdoorn and wage-push effect					
Naastepad (2006)	The Netherlands	1960-2000, OECD	OLS (sometimes with an AR(1) adjustment)	$\hat{y} = f(\hat{Y}, \hat{w})$	$(dy/y)/(dY/Y) = 0.63$, $(dy/y)/(dw/w) = 0.52$
Vergeer/Kleinknecht (2007)	19 OECD countries	1960-2004; Groningen Growth and Development Centre	GLS and instrumental variables, Panel data estimation, no causality tests	$\hat{y} = f(\hat{w}, \hat{y}_{t-1}, \hat{Y}$, GAP, K/Y, s_sh)	$(dy/y)/(dY/Y) = 0.23...0.26$, $(dy/y)/(dw/w) = 0.24...0.34$
Notes: y: labour productivity, w: real wage, E: employment, Y: GDP, wh: working hours, IQ: investment share, K: capital stock, s_sh: share of services in GDP, Y_c: per capita GNP, X: volume of goods exports, I: investment in machinery and equipment, U: standardized unemployment rate					

More recent studies, or studies not included in the McCombie/Pugno/Soro (2002b) overview, confirm these results (Table 4).[26] Schnur (1990) estimates the Verdoorn equation for Germany from 1962-1988 and finds a significant elasticity of about 0.54 to 0.6 for the whole economy and of around 0.4 for the manufacturing sector. Jasperneite/Allinger (1998) estimate the typical Verdoorn equation for West-Germany from 1988-1998 and find significant coefficients ranging between 0.64 and 0.67. Walterskirchen (1999) presents some cross-country analysis (1988-1998) as well as country specific estimations (1970-1998) for the USA, Germany, the UK, France, the Netherlands and Austria, among others. He obtains Verdoorn-coefficients between 0.47 (USA) and 0.76 (Austria). Leon-Ledesma (2002) uses some further control variables, like the investment share, the capital stock as a proxy of innovations and the technology gap to the technological frontier, and gets a Verdoorn coefficient about 0.64 and 0.67 for a cross-country regression containing 18 countries in the period 1965-1994. In a pooled regression for average values over the four business cycles from 1960-1989 in 16 OECD countries (including Germany, the UK, the USA, the Netherlands and Austria), Cornwall/Cornwall (2002) show that productivity growth depends on the productivity gap to the USA ('catching up factor'), on exports and investment demand, as well as the unemployment rate ('demand factors'), and on per-capita-income (indicator for structural change towards services). On average over the countries, structural change towards services and the decreasing productivity gap to the USA explain 50% of the productivity slowdown from the first sub-period (1960-1973) to the second (1974-1989). The other 50% of the slowdown are explained by the demand factors.[27] Finally, Uni (2007) finds rising effects of output growth on productivity growth for the US (1978-1987, 1988-2001) and the Japanese (1976-1990, 1991-2003) manufacturing sectors from the first to the second period estimated.

Wage-push factors for productivity growth are confirmed by Marquetti (2004). He finds co-integration between real wages and labour productivity in the USA from 1869-1999. Real wages are Granger-causal for labour productivity, but labour productivity is not Granger-causal for real wages. Naastepad (2006) in her country study for the Netherlands from 1960-

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[26] We have not included the results by Atesoglu/Smithin (2006) who estimate partial adjustment equations for several countries with productivity growth being determined by GDP growth and by lagged productivity growth. Calculating the long-run Verdoorn coefficient from their estimations yields implausible values for Germany (2.22), Japan (9.98), France (4.31), Italy (5.54) and even the UK (0.95). Only for the USA (0.7) and Canada (0.57) the long-run Verdoorn coefficients are in a plausible range.

[27] See also Leon-Ledesma/Thirlwall (2002) who have shown for 15 OECD countries (including France, Germany, the UK, the USA, the Netherlands and Austria) in the period 1960-1995 that the natural rate of growth, i.e. the sum of labour force growth and productivity growth, is positively affected by actual GDP growth. The natural rate is thus endogenous with respect to the demand determined actual GDP growth rate, with both productivity growth and labour supply growth being the endogeneity channels.

2000 includes a wage-push effect alongside the Verdoorn effect into her estimation of the productivity equation. The elasticity of productivity growth with respect to real GDP growth is 0.63, and with respect to real wage growth it is 0.52. Vergeer/Kleinknecht (2007) in panel-data regressions for 19 OECD countries from 1960-2004, including Germany, France, the UK, the USA, the Netherlands and Austria, also estimate the effects of aggregate demand and real wage growth on productivity growth. They include several other variables into their estimations, such as the productivity gap to the technology leader ("catching up"), lagged labour productivity growth ("path dependence"), the share of the service sector (sectoral change), and country as well as time dummies. The estimated Verdoorn effect is between 0.23 and 0.26, and the estimated wage push effect is between 0.24 and 0.34.

5. Estimation results for productivity growth

5.1 Data and estimation strategy

We applied single equation estimations in order to identify the effects of output growth and distribution on productivity growth for six countries: Austria, France, Germany, the Netherlands, the UK and the USA. We used annual data from the AMECO database (European Commission 2007) which cover a period from 1960 to 2007.[28] Productivity growth ($\hat{y}$) is the growth of real output per person employed (full-time equivalents) for the economy as a whole. For the Verdoorn effect we used the growth rate of real GDP ($\hat{Y}$) as a determinant of productivity growth. For the wage-push effect real wage growth ($\hat{w}$), as in Naastepad (2006), was applied first. For the reasons given in the theoretical model, however, we hold that the wage-push effect should be better indicated by the profit share. Therefore, we estimated a second equation more consistent with our theoretical model with the profit share (h) instead of real wage growth. Two control variables were included in order to avoid the problem of unobserved variables. The share of manufacturing output in total GDP (sh_m) controls for the effects of structural change on economy-wide productivity growth. Another impact controlled for is the potential for catching up with the technology leader. Here we used the labour productivity difference between the USA and the respective country under investigation (GAP). We therefore estimated the following general equations:

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[28] See the data description in the appendix.

$$\hat{y} = f(\hat{Y}, \hat{w}, sh\_m, GAP), \quad (13)$$

$$\hat{y} = f(\hat{Y}, h, sh\_m, GAP). \quad (14)$$

The estimation strategy was as follows. All level variables were transformed into logs. First we tried to estimate an error-correction-model following the method suggested by Pesaran et al. (2001). They simulated critical value bounds for an F-Test in order to determine long-run relationships, independently of the degree of integration of the respective variables.[29] If no cointegration was found, dynamic difference models with lags up to three periods were estimated. Applying the ADF-test, some variables seemed to be I(0), but the ADF-GLS-test[30] could not reject the null hypothesis of the existence of a unit root, so that we included the variables in first differences. Insignificant variables were excluded and the equations were re-estimated. All necessary tests were applied. The lags in the difference equations were chosen in order to cope with cyclical variations in the variables and to capture long-run effects. Thus, some effects in our study – especially the Verdoorn effect – seem to be relatively small compared to other studies reviewed in the previous section, because in most of those studies only the contemporaneous effect is considered.[31]

5.2 Estimation results

Starting with equation (13), only for Germany an error-correction model could be estimated:

$$\begin{aligned} & d[\log(y_t)] \\ & = a_0 c + a_1 \log(y_{t-1}) + a_2 \log(Y_{t-1}) + a_3 \log(w_{t-1}) + a_4 sh\_m_{t-1} + a_5 \log(GAP_{t-1}) \\ & + a_6 \sum d[\log(y_{t-j})] + a_7 \sum d[\log(Y_{t-i})] + a_8 \sum d[\log(w_{t-i})] + a_9 \sum d[sh\_m_{t-i}] \quad (13a) \\ & + a_{10} \sum d[\log(GAP_{t-i})] + e_t, \\ & i = 1,2,3, \; j = 1,2 \end{aligned}$$

For the other countries we estimated dynamic difference equations of the following form:

$$\begin{aligned} & d[\log(y_t)] \\ & = b_0 c + b_1 \sum d[\log(y_{t-j})] + b_2 \sum d[\log(Y_{t-i})] + b_3 \sum d[\log(w_{t-i})] \\ & + b_4 \sum d[sh\_m_{t-i}] + b_5 \sum d[\log(GAP_{t-i})] + e_t, \\ & i = 0,1,2,3, \; j = 1,2 \end{aligned} \quad (13b)$$

The coefficients (a_2) and (b_2) are the Verdoorn coefficients, the coefficients (a_3) and (b_3) are the wage-push coefficients. The long-run coefficients of the ECM were calculated by dividing the level variable of the exogenous variable by the absolute value of the error-correction term

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[29] See table A1 in the appendix for ADF and ADF-GLS tests on the variables.

[30] See Elliot/Rothenberg/Stock (1992) for the construction of this test.

[31] See also the critique in Vergeer/Kleinknecht (2007).

(e.g. $a_2/|a_1|$). The long-run coefficients for the difference equations were obtained by summing up the coefficients of the exogenous variables and dividing them by one minus the coefficient of the lagged endogenous variable (e.g. $b_3/(1-b_1)$). Table 5 shows the estimation results.

The long-run coefficients were highly significant and show the expected sign. The explanatory content (R^2) is relatively high. When necessary, the models were corrected for outliers in order to prevent heteroskedasticity. The test results verify robust models. For Germany the Wald-Test can reject the null that the level coefficients are different from zero at 1% significance. Hence, there exists a long-run equilibrium between the variables.

The estimation results for the Verdoorn effect are generally smaller compared to other studies. This difference may be due to the introduction of lagged variables in our approach, i.e. other studies might have captured short-run cyclical Okun effects rather than the Verdoorn effect, as Vergeer/Kleinknecht (2007) have recently argued. The strongest influences of output growth on productivity growth were found for France and the lowest for the USA. A one percent increase of output raises labour productivity by 0.54 percent in France. The results for Germany (0.43) and the Netherlands (0.45) are of similar magnitude. For Austria and the UK we have found smaller values (0.33 and 0.23) and for the USA the long-run output elasticity of labour productivity is only 0.11.

The effect of real wages on labour productivity is significantly positive. The elasticities are in the range of other studies, but differ between countries. The highest values were found for Austria. A one percent increase in real wages raises labour productivity by approximately 0.67 percent. The values for the Netherlands and USA are of similar size (0.33 and 0.36). The elasticities for Germany (0.32), France (0.31) and the UK (0.25) are lower.

Having so far confirmed the results from the literature (i.e., Naastepad 2006, Vergeer/Kleinknecht 2007), in the next step we estimated the, in our view, more appropriate productivity equation (14). Inspecting the data, however, reveals that there is a structural break in the relationship between the profit share and productivity growth in the early/mid 1980s, except for the UK and the USA (Figures 4a-f).[32]

[32] Applying the QLR-test as well as the Chow-test in order to determine structural breaks does not obtain any appropriate results. This could be due to the fact that other structural breaks as in 1979 and 1982 overcompensate the structural break in the mid 1980s. But the sub period specific trends in the figures 4a-f show a clear switch.

Table 5: Determinants of productivity growth in Germany, France, the Netherlands, Autria, the UK and the USA, 1960-2007						
1960-2007	**Germany**	**France**	**Netherlands**	**Austria**	**UK**	**USA**
	Endogenous: d[log(y)]					
Const	-0.17			0.00	0.02	0.01
p-value	*0.30*			*0.95*	*0.00*	*0.00*
log(Y_{t-1})	0.12					
p-value	*0.02*					
log(y_{t-1})	-0.28					
p-value	*0.00*					
log(w_{t-1})	0.09					
p-value	*0.04*					
sh_m$_{t-1}$	-0.10					
p-value	*0.51*					
log(GAP_{t-1})	0.04					
p-value	*0.00*					
d[log(y_{t-1})]		0.74	0.58	0.76		0.20
p-value		*0.00*	*0.00*	*0.00*		*0.02*
d[log(Y_t)]		0.60	0.63	0.76	0.51	0.56
p-value		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
d[log(Y_{t-1})]		-0.69	-0.65	-0.81		-0.47
p-value		*0.00*	*0.00*	*0.00*		*0.00*
d[log(Y_{t-2})]	-0.35	0.10		0.13	-0.58	
p-value	*0.00*	*0.04*		*0.00*	*0.00*	
d[log(Y_{t-3})]	-0.29	0.13	0.21		0.12	
p-value	*0.02*	*0.00*	*0.00*		*0.01*	
d[log(Y_{t-4})]					0.18	
p-value					*0.00*	
d[log(w_t)]			0.14		0.25	0.29
p-value			*0.00*		*0.00*	*0.00*
d[log(w_{t-1})]				0.16		
p-value				*0.00*		
d[log(w_{t-3})]		0.08				
p-value		*0.05*				
d(sh_m$_t$)				-0.53		-1.02
p-value				*0.00*		*0.00*
d(sh_m$_{t-1}$)				0.46	0.39	
p-value				*0.02*	*0.00*	
d(sh_m$_{t-2}$)					0.41	
p-value					*0.00*	
d(sh_m$_{t-3}$)	0.76	-0.93				
p-value	*0.02*	*0.00*				
d[log(GAP_t)]			*-0.02*			
p-value			*0.09*			
d[log(GAP_{t-2})]				0.03		
p-value				*0.05*		
(dy/y)/(dY/Y)	**0.43**	**0.54**	**0.45**	**0.33**	**0.23**	**0.11**
(dy/y)/(dw/w)	**0.32**	**0.31**	**0.33**	**0.67**	**0.25**	**0.36**
Adj. R^2	0.71	0.98	0.97	0.96	0.90	0.89
D-W statistics	2.10	1.97	2.22	1.80	1.88	1.68
Reset-Test, p-value	0.37	0.70	0.34	0.79	0.18	0.98
White’s Test, p-value	0.92	0.19	0.25	0.40	0.35	0.29
Breusch-Pagan, p-value	0.97	0.77	0.43	0.63	0.64	0.63
Normal distribution, p-value	0.60	0.57	0.66	0.76	0.57	0.17
LM-Test(3), p-value	0.26	0.21	0.24	0.69	0.66	0.47
CUSUM, p-value	0.24	0.18	0.65	0.76	0.53	0.68
Wald-Test, F-stat	19.22***					
Dummies and determinants		Dummy 1976	Dummy 1979 and 1981	Dummy 1966 and 1982	Dummy 1974 and 1981, time trend	Dummy 1963, 1976, 1978 and 1984

Notes: y: labour productivity, Y: GDP, w: real wage, sh_m: share of manufacturing sector, GAP: labour productivity gap to the USA

Figure 4a: Profit share and labour productivity growth, Germany, 1960-2007

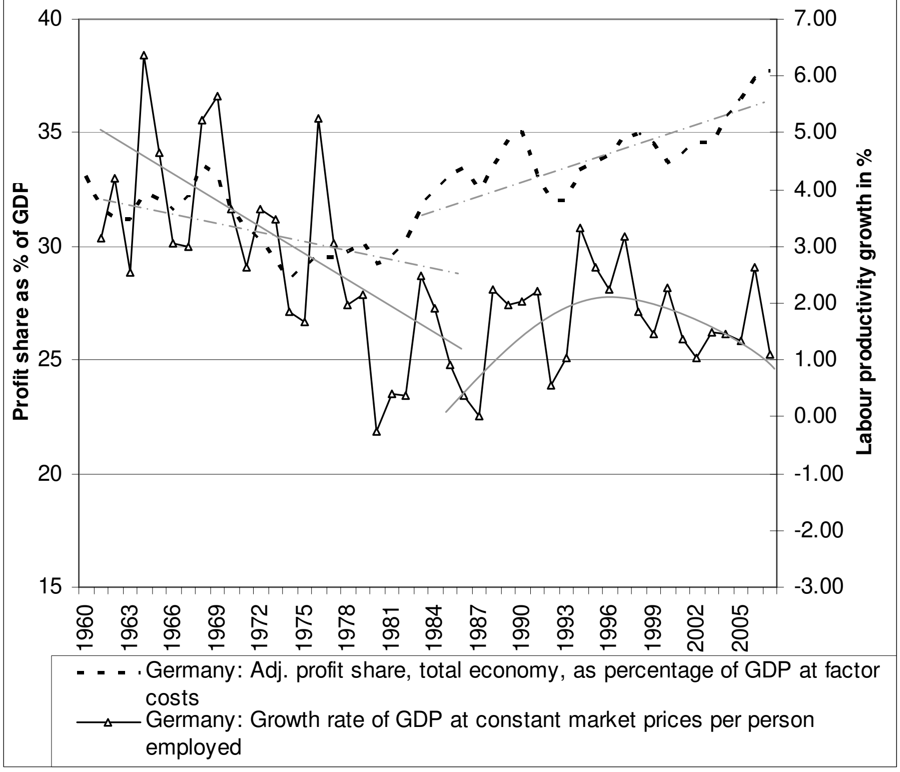
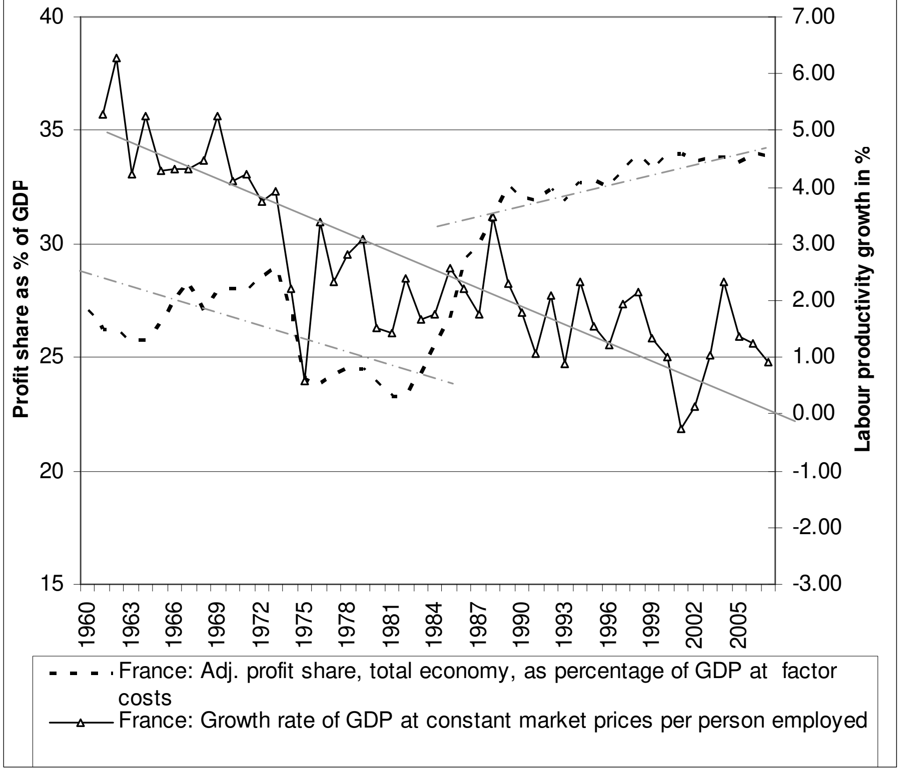


Figure 4b: Profit share and labour productivity growth, France, 1960-2007



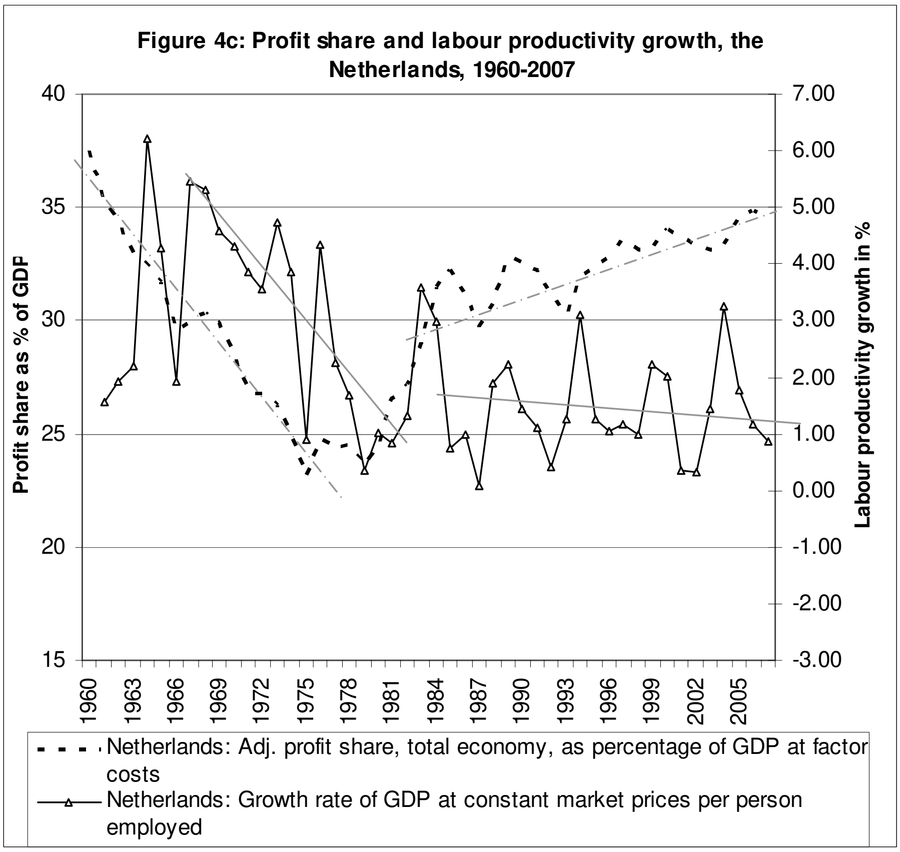


Figure 4c: Profit share and labour productivity growth, the Netherlands, 1960-2007
Profit share as % of GDP
Labour productivity growth in %
Netherlands: Adj. profit share, total economy, as percentage of GDP at factor costs
Netherlands: Growth rate of GDP at constant market prices per person employed


Figure 4d: Profit share and labour productivity growth, Austria, 1960-2007
Profit share as % of GDP
Labour productivity growth in %
Austria: Adj. profit share, total economy, as percentage of GDP at factor costs
Austria: Growth rate of GDP at constant market prices per person employed

Figure 4e: Profit share and labour productivity growth, UK, 1960-2007

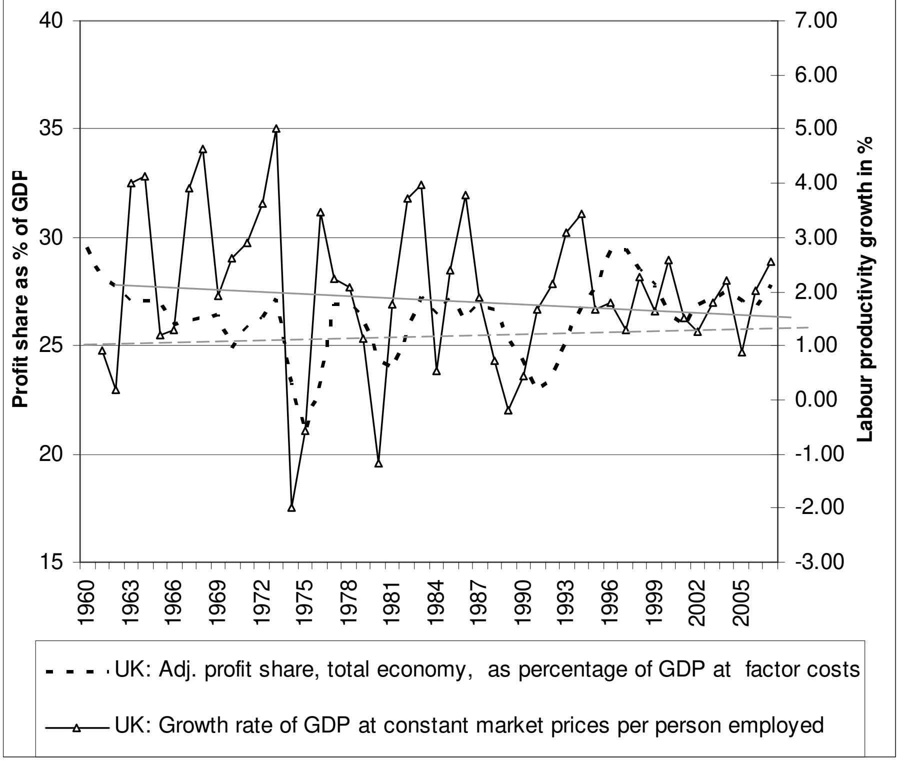
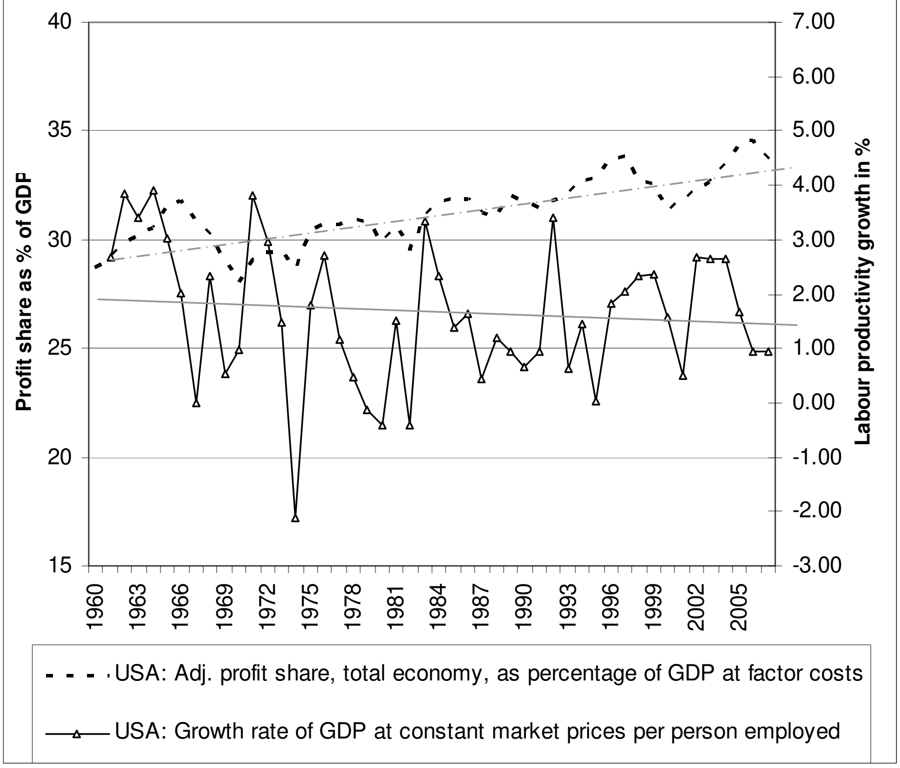


Figure 4f: Profit share and labour productivity growth, USA, 1960-2007



Considering this aspect, we decided to estimate sub-periods to account for this structural break for Austria, France, Germany and the Netherlands. For the USA and UK we estimated the whole period. For both countries we could not find any cointegration relationship. So we had to estimate difference models for all countries:

$$\begin{aligned} d[\log(y_t)] &= b_0 c + b_1 \sum d[\log(y_{t-j})] + b_2 \sum d[\log(Y_{t-i})] + b_3 \sum d[h_{t-i}] \\ &+ b_4 \sum d[sh\_m_{t-i}] + b_5 \sum d[\log(GAP_{t-i})] + e_t, \\ &i = 0,1,2,3, \;\; j = 1,2 \end{aligned} \tag{14a}$$

Table 6 for the UK and the USA shows that the R^2 are relatively high and the models are robust. For the UK the null hypothesis of the Breusch-Pagan test can only be rejected at 10% significance, but the White test confirms homoskedasticity of the residuals. The Verdoorn effects are higher than for the first estimation, due to the fact that for both models only *current* GDP growth is significant. However, we can again confirm the general known results. The contemporaneous relations for the UK report that an increase in output by one percent raises the labour productivity by 0.61 percent. In the USA this effect is about 0.39 percent. The distributional effects are in accordance with our theoretical hypothesis: An increase in the profit share reduces labour productivity growth. A one percentage point increase in the profit share decreases labour productivity by 0.46 percent in the UK and by about 0.33 percent in the USA.

The models for the other countries are also robust, as can be seen in Table 7. For France and the Netherlands the Durbin-Watson statistics are very low in the first sub-period, but the LM-Test cannot reject the null hypothesis that there is no autocorrelation for the first as well as for the third lag.[33] The same applies for Germany, the Netherlands and Austria in the second sub-period. In both periods and for all countries the R^2's are relatively high. All tests verify the efficiency and stability of the equations. Both periods show a significant influence of the Verdoorn effect. The wage-push effect, measured by the profit share, does only seem to hold for the second period, with the exception of France where we have the expected sign but no statistical significance.

Generally we found, that the Verdoorn effect is stronger in the first sub-period than in the second, except for Austria. In Germany, this decline is most pronounced, from 0.86 in the first period to 0.27 in the second.

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[33] Since we included lags of the endogenous variable, the Durbin-Watson statistics is biased. See (Kirchgässner/Wolters 2006: 17).

Table 6: Determinants of productivity growth in the UK and the USA, 1960-2007		
	UK	**USA**
	Endogenous: d[log(y)]	
Const	0.01	0.00
p-value	*0.00*	*0.12*
d[log(Y_t)]	0.61	0.39
p-value	*0.00*	*0.00*
d(h_{t-2})	-0.46	
p-value	*0.00*	
d(h_{t-3})		-0.33
p-value		*0.02*
d(sh_m_{t-1})		-1.53
p-value		*0.00*
d(sh_m_{t-2})	0.21	
p-value	*0.11*	
d[log(GAP_t)]	-0.08	
p-value	*0.01*	
(dy/y)/(dY/Y)	**0.61**	**0.39**
(dy/y)/(dh)	**-0.46**	**-0.33**
Adj. R^2	0.69	0.73
D-W statistics	1.65	1.67
Reset-Test, p-value	0.39	0.40
White's Test, p-value	0.29	0.93
Breusch-Pagan, p-value	0.09	0.92
Normal distribution, p-value	0.48	0.63
LM-Test(3), p-value	0.66	0.57
CUSUM, p-value	0.27	0.52
Dummies and determinants	Dummy 1988	Dummy 1964, 1979, 1987 and 1992
Notes: y: labour productivity, Y: GDP, w: real wage, sh_m: share of manufacturing sector, GAP: labour productivity gap to USA		

Table 7: Determinants of productivity growth in Germany, France, the Netherlands and Austria, 1960-2007 (sub-periods)								
	Germany		**France**		**Netherlands**		**Austria**	
	1960-1984	**1985-2007**	**1960-1982**	**1983-2007**	**1960-1983**	**1984-2007**	**1960-1983**	**1985-2007**
	Endogenous: d[log(y)]							
Const		0.01	0.01	0.03	0.01	0.01	0.05	0.01
p-value		*0.03*	*0.00*	*0.00*	*0.00*	*0.04*	*0.00*	*0.00*
d[log(Y_t)]	0.59	0.13	0.70	0.36	0.66	0.27	0.32	0.48
p-value	*0.00*	*0.08*	*0.00*	*0.00*	*0.00*	*0.01*	*0.00*	*0.00*
d[log(Y_{t-1})]	-0.35							-0.18
p-value	*0.04*							*0.02*
d[log(y_{t-1})]	0.72	0.52						0.32
p-value	*0.00*	*0.00*						*0.00*
d(h_t)	0.80				0.29		0.67	
p-value	*0.00*				*0.01*		*0.00*	
d(h_{t-1})	-0.71	-0.42		-0.07				-0.46
p-value	*0.00*	*0.01*		*0.69*				*0.00*
d(h_{t-2})			0.15	-0.1		-0.33		
p-value			*0.01*	*0.59*		*0.00*		
d(sh_m_t)		0.37						
p-value		*0.05*						
d(sh_m_{t-1})		-0.98						
p-value		*0.00*						
d(sh_m_{t-2})		-0.34						
p-value		*0.10*						
d[log(GAP_{t-1})]		-0.07						
p-value		*0.00*						
d[log(GAP_{t-2})]			0.03		-0.05			
p-value			*0.01*		*0.03*			
(dy/y)/(dY/Y)	**0.86**	**0.27**	**0.70**	**0.36**	**0.66**	**0.27**	**0.32**	**0.44**
(dy/y)/(dh)	**0.32**	**-0.87**	**0.15**	**-**	**0.29**	**-0.33**	**0.67**	**-0.68**
Adj. R^2	0.96	0.85	0.96	0.56	0.90	0.60	0.94	0.91
D-W statistics	2.24	2.46	1.51	1.82	1.60	2.48	1.97	2.45
Reset-Test, p-value	0.98	0.85	0.78	0.22	0.81	0.70	0.98	0.75
White's Test, p-value	0.23	0.47	0.85	0.43	0.48	0.53	0.31	0.25
Breusch-Pagan, p-value	0.42	0.72	0.34	0.18	0.80	0.42	0.47	0.13
Normal distribution, p-value	0.85	0.98	0.19	0.61	0.83	0.39	0.79	0.52
LM-Test(3), p-value	0.87	0.53	0.48	0.96	0.65	0.26	0.40	0.58
Cusum, p-value	0.64	0.12	0.59	0.99	0.20	0.26	0.83	0.96
Dummies and Determinants		Dummies 2005 and 2006	Dummy 1968	Dummy 2001, time trend	Dummies 1979 and 1980	Dummies 1984 and 2004	Dummy 1965, time trend	Dummy 1996
Notes: y: labour productivity, Y: GDP, w: real wage, sh_m: share of manufacturing sector, GAP: labour productivity gap to USA								

For distribution we found a significantly positive effect of the profit share on productivity growth in all four countries first period, which is hardly to square with our theoretical arguments. In the second sub-period, from the early/mid 1980s until 2007, however, the expected adverse relationship between the profit share and productivity growth was obtained, except for the statistical significance problem with France. In Germany, an increase in the profit share by one percentage point has decreased productivity by 0.87 percent. In Austria the effect was 0.68 percent, and in the Netherlands it was 0.33 percent. The change in the relationship between distribution and productivity growth in the Continental European countries remains to be assessed in further research. Here we can only speculate that the relationship between the profit share and productivity growth may be non-linear, as for example Lima (2004) has suggested.[34]

6. Conclusions

Starting from a simple theoretical model for an open economy with productivity growth we have examined the effects of a change in functional income distribution on the demand, the productivity and the overall regime of the economy. With wage-led aggregate demand the negative effects of an increasing profit share on the demand and the productivity regime reinforce each other and an overall contractive regime emerges. If aggregate demand is profit-led, however, different overall regimes may arise in the face of an increasing profit share, depending on the relative strength of the effects of redistribution on the demand and on the productivity regime: contractive or expansive effects throughout on capacity utilisation, capital accumulation and productivity growth, or an intermediate regime with positive effects on economic activity and capital accumulation, but negative effects on productivity growth.

Recent empirical studies imply that the medium- to long-run demand regime in large and medium-sized open economies, as in Germany, France, the UK and the USA, tends to be wage-led, whereas for small open economies, as the Netherlands and Austria, some studies have obtained profit-led results. Our estimations of the productivity regime for these six countries in the period from 1960 to 2007 have confirmed the prevalence of a Verdoorn effect, i.e. a positive impact of GDP growth on productivity growth. In countries with wage-led demand regime, therefore, redistribution at the expense of labour does not only weaken

[34] In Lima’s (2004) model, the profit share has twofold effects on productivity growth: it affects the incentive to innovate, as in our model, but it also affects the funds to innovate. However, he has no effect of demand on productivity growth in his model.

aggregate demand and GDP growth, but through the Verdoorn effect also productivity growth is affected in the negative. We have also introduced wage-push variables into the estimations of the productivity equations. The effect of real wage growth on productivity growth has been confirmed for all six countries. However, since only real wage growth exceeding productivity growth eats into unit profits and the profit share imposing cost-cutting pressure on firms, we have replaced real wage growth by the profit share in the estimations of the productivity equations, consistent with our theoretical model. A negative effect of the profit share on productivity growth was found for the UK and the USA for the whole period, and for Austria, Germany, and the Netherlands for the period from the early/mid 1980s to 2007. For France no statistical significant effect could be found. Through the wage-push channel a falling wage share also has a directly negative impact on productivity growth.

Summing up, in those wage-led economies in which we also found a statistically significant negative effect of the profit share on productivity growth, as in Germany, the UK and the USA, the dampening effects of a rising profit share on the demand and the productivity regime reinforce each other and an overall contractive effect of a rising profit share emerges. In France with a wage-led demand regime but no significant direct effect of the profit share on productivity growth, we also obtain an overall contractive effect of a rise in the profit share, because the negative aggregate demand effect also spills over to productivity growth via the Verdoorn channel.

In countries with a profit-led demand regime, however, as probably in the Netherlands or in Austria, the expansive effects of an increasing profit share on aggregate demand go along with a partially depressive effect on productivity growth, which however may be compensated for by the expansive effect via GDP growth. Therefore, the character of the overall regime in these countries (contractive, intermediate or expansive) remains to be determined in more detailed empirical analysis which focuses on the interaction of demand and productivity regime.

In those economies with a wage-led demand regime, however, a clear-cut result for economic policies is obtained from our analysis, at least for the period since the mid 1980s: Redistribution at the expense of labour will not only be harmful for aggregate demand and economic activity in the short run, it will also have depressing effects on capital accumulation and productivity growth, and hence on potential growth and the 'natural rate of growth' in the long run. If potential feedbacks on distribution, not discussed in the present paper, would be included, the danger of cumulative downwards processes in these economies are quite obvious, with falling wage shares, falling GDP, capital stock and productivity growth rates reinforcing each other.

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Appendix

A1: Solution for overall equilibrium and for overall effects of a change in the profit share on capacity utilisation and productivity growth

Inserting equations (10a) and (8) yields the overall equilibrium rates of capacity utilisation and productivity growth:

$$u^{**} = \frac{\alpha + (\tau - \theta\omega)h + \psi e_r(h) + \omega\eta}{[s_W + (s_\Pi - s_W)h]\frac{1}{v} - \beta + \phi - \omega\rho}. \tag{A1}$$

$$\hat{y}^* = \frac{(\eta - \theta h)\left\{[s_W + (s_\Pi - s_W)h]\frac{1}{v} - \beta + \phi\right\} + \rho[\alpha + \tau h + \psi e_r(h)]}{[s_W + (s_\Pi - s_W)h]\frac{1}{v} - \beta + \phi - \omega\rho}. \tag{A2}$$

The effect of a change in the profit share on the overall equilibrium rate capacity utilisation is given by:

$$\frac{\partial u^{**}}{\partial h} = \frac{\tau - (s_\Pi - s_W)\frac{u}{v} + \psi\frac{\partial e_r}{\partial h} - \theta\omega}{[s_W + (s_\Pi - s_W)h]\frac{1}{v} - \beta + \phi - \rho\omega}, \tag{A1'}$$

The denominator has to be positive from the existence and stability condition of the overall equilibrium (equation 11). There are positive effects of an increasing profit share via investment (τ) and net exports [$\psi(\partial e_r / \partial h)$], a negative effect via consumption [$-(s_\Pi - s_W)(u/v)$], and now also negative effects via productivity growth ($-\theta\omega$). The overall effect may hence be positive (profit-led) or negative (wage-led), depending on the strength of the individual effects.

For the effect of a change in the profit share on equilibrium rate of productivity growth we obtain:

$$\frac{\partial \hat{y}^*}{\partial h} = \frac{\rho\left[\tau - (s_\Pi - s_W)\frac{u}{v} + \psi\frac{\partial e_r}{\partial h}\right] - \theta\left\{[s_W + (s_\Pi - s_W)h]\frac{1}{v} - \beta + \phi\right\}}{[s_W + (s_\Pi - s_W)h]\frac{1}{v} - \beta + \phi - \rho\omega} \tag{A2'}$$

As can easily be seen, the total effect of a change in the profit share is composed of two sub-effects.[35] The effect via goods market activity $\{\rho[\tau - (s_\Pi - s_W)(u/v) + \psi(\partial e_r / \partial h)]\}$ may be

[35] Again, the denominator is positive from the existence and stability condition of overall equilibrium.

positive or negative depending on the nature of the demand regime. If demand is profit-led, this effect will be positive, if it is wage-led, this effect will be negative. The second effect ($-\theta\{[s_W + (s_\Pi - s_W)h](1/v) - \beta + \phi\}$) is negative in any case, because the term in brackets has to be positive from the goods market stability condition. Therefore, in a wage-led demand regime, the overall effect of an increasing profit share on productivity growth will be negative, whereas in a profit-led demand regime the overall effect of a rising profit share on productivity growth may be either positive or negative.

A2: Data definitions and data source

All variables are obtained from the AMECO database (European Commission 2007)

y	Gross domestic product at 2000 market prices per person employed (full-time equivalents)
Y	Gross domestic product at 2000 market prices
w	Real compensation per employee, deflator private consumption: total economy
h	1 minus adjusted wage share (total economy), as percentage of GDP at factor cost (wage share: compensation per employee as percentage of GDP at factor cost per person employed)
sh_m	Share of gross value added in manufacturing industry in gross domestic product at 2000 market prices
GAP	Difference of gross domestic product at 2000 market prices per person employed (full-time equivalents) with respect to the USA (for all countries in levels and euro)

Table A1: Stationarity Tests: 1960-2007								
Augmented Dickey-Fuller Test					Augmented Dickey-Fuller-GLS Test			
H0: The time series has a unit root; Max. 2 lags → automatic lag selection					H0: The time series has an unit root; One lag			
Country	**Variable**	**T-statisitics**	**Determinant**		**Country**	**Variable**	**T-statistics**	**Determinant**
Germany	log(Y)	-2.09	C,t		Germany	log(Y)	-1.70	C, t
	d[log(Y)]	-4,80***	C					
	log(y)	-2.62	C, t			log(y)	-1.21	C, t
	d[log(y)]	-2.85**	C					
	log(w)	-1.82	C, t			log(w)	-1.05	C, t
	d[(log(w)]	-3.14**	C					
	h	-1.57	C, t			h	-1.33	C, t
	d(h)	-5.46***						
	sh_m	2.17	C, t			sh_m	-1.73	C, t
	d(sh_m)	-5.20***						
France	log(Y)	-3.12	C, t		France	log(Y)	-1.07	C, t
	d[log(Y)]	-3.12**	C					
	log(y)	-4.06**	C, t			log(y)	-0.63	C, t
	d[log(y)]	-2.20**	C					
	log(w)	-4.54***	C, t			log(w)	-1.02	C, t
	d[(log(w)]	-2.22**						
	h	-1.93	C, t			h	-1.84	C, t
	d(h)	-4.51***						
	sh_m	-2.04	C, t			sh_m	-1.25	C, t
	d(sh_m)	-2.28**						
Netherlands	log(Y)	-2.80	C, t		Netherlands	log(Y)	-1.77	C, t
	d[log(Y)]	-3.52**	C					
	log(y)	-2.09	C, t			log(y)	-1.10	C, t
	d[log(y)]	-4.94***	C, t					
	log(w)	-2.83	C, t			log(w)	-1.52	C, t
	d[(log(w)]	-1.44						
	h	-3.00	C, t			h	-1.29	C, t
	d(h)	-5.13***						
	sh_m	-2.14	C, t			sh_m	-1.39	C, t
	d(sh_m)	-6.77***						
Austria	log(Y)	-1.92	C, t		Austria	log(Y)	-1.31	C, t
	d[log(Y)]	-5.92***	C, t					
	log(y)	-1.77	C, t			log(y)	-1.25	C, t
	d[log(y)]	-1.03				d[log(y)]	-2.12**	C
	log(w)	-1.60	C, t			log(w)	-1.44	C, t
	d[(log(w)]	-4.57***	C, t					
	h	-1.43	C, t			h	-1.16	C, t
	d(h)	-7.00***						
	sh_m	-1.67	C, t			sh_m	-2.12	C, t
	d(sh_m)	-4.74***						
UK	log(Y)	-2.99	C, t		UK	log(Y)	-2.97*	C, t
	d[log(Y)]	-5.38***	C					
	log(y)	-2.78	C, t			log(y)	-2.01	C, t
	d[log(y)]	-6.80***	C					
	log(w)	-1.86	C, t			log(w)	-1.52	C, t
	d[(log(w)]	-6.05***	C					
	h	-4.10***	C			h	-3.51**	C, t
	d(h)	-5.91***						
	sh_m	-1.75	C, t			sh_m	-1.72	C, t
	d(sh_m)	-5.41***						
USA	log(Y)	-4.22*	C, t		USA	log(Y)	-2.65	C, t
	d[log(Y)]	-5.21***	C					
	log(y)	-3.31*	C, t			log(y)	-1.72	C, t
	d[log(y)]	-5.17***	C					
	log(w)	-2.78	C, t			log(w)	-1.77	C, t
	d[(log(w)]	-3.99***	C					
	h	-3.81**	C, t			h	-3.87***	C, t
	d(h)	-6.36***						
	sh_m	-2.96	C, t			sh_m	-2.89	C, t
	d(sh_m)	-7.32***						
Notes: C: constant, t: time trend								

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