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The Dutch productivity slowdown: the culprit at last?

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Abstract

Two aspects of the recent performance of the Dutch economy (1982–2001) have attracted wide international attention: (1) rapid employment growth and (2) a significant slowdown in labour productivity growth. This paper argues that the shift from a high-productivity, low-employment towards a low-productivity, high-employment growth path constitutes a structural change set off by the policy of low wage growth launched in 1982. Various theoretical perspectives—including neo-classical substitution, induced technological change, vintage and the Verdoorn Law—point to channels through which wage growth restraint may hold back labour productivity growth. Our growth accounting analysis—based on these perspectives—suggests that a substantial part of the Dutch labour productivity growth slowdown can be attributed to the wage growth slowdown.
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1. Introduction

Through the famous agreement of Wassenaar in 1982, Dutch trade unions agreed to moderate their wage demands in an attempt to reduce unemployment (which was very high at the time). Since then, real wage growth in The Netherlands has slowed down, and job growth increased substantially, both relative to earlier periods and relative to other OECD

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countries. This impressive job growth was accompanied by a relatively large decline (in international comparison) in the growth rate of labour productivity.

In the policy debate there is broad agreement that the impressive job growth in the country over the past 15 years can be attributed to the policy of low wage growth, while the slowdown in labour productivity growth cannot be attributed to the low wage growth. However, as we shall argue in this paper (Section 2), there are various theoretical reasons to assume that the high employment growth and the slowdown in labour productivity growth are, in fact, two sides of the same coin. The purpose of this paper is to test the hypothesis that wage moderation has not influenced labour productivity growth in The Netherlands. Before going into the empirical testing, Section 3 presents the areas of agreement, or the ‘stylised facts’ of Dutch employment and productivity growth. Doing so is not only in itself important, but it will also be helpful in providing a common framework within which the Dutch productivity crisis can be discussed. Sections 4 and 5 present the results of empirical tests of the hypothesis that the Dutch productivity slowdown is unrelated to the policy of wage moderation. In Section 6, we conclude that wage moderation is indeed the major culprit of the Dutch productivity slowdown.

2. A critique of the policy of wage restraint

In the agreement of Wassenaar in 1982, wage moderation was envisaged to raise employment growth through the following three channels:

1. Real wage moderation raises both the demand for and the supply of labour.
2. Low wage growth restrains the growth of unit labour cost (ULC), enabling firms to compete with low wage costs elsewhere. The improved international competitiveness would stimulate output and employment through the export multiplier.
3. A redistribution of income away from wages and towards profits raises the profitability of investment, making it more attractive for (financial and physical) capital to remain within the country. The resulting higher investment raises output and employment through the income multiplier.

In the literature on the Dutch ‘employment miracle’, there is broad agreement that the impressive job growth in the country in the past 15 years has been brought about through the above three channels. There are, however, two problems with this argument:

1. The growth of unit labour cost depends not only on wage growth but also on labour productivity growth. Lower wage growth will reduce ULC growth and raise profitability only if it is not offset by lower labour productivity growth.
2. Although wage growth is commonly held to be without any consequence for labour productivity growth, the latter may, in fact, be influenced by the former.

If wage moderation negatively influences labour productivity growth, the gains of wage moderation in terms of lower ULC growth and a higher profit share will be eroded—at least in part—by a productivity growth slowdown. One may thus end up in a vicious circle of wage growth restraint and labour productivity slowdown, necessitating (in the view of the wage moderation advocates) further wage growth restraint. The hypothesis that wage growth restraint retards labour productivity growth is informed by various parts of economic theory, given as follows.

1. *Neo-classical substitution*: A fall in the price (w) of labour relative to the price (r) of capital induces firms to substitute labour (L) for capital (K), thus reducing the capital intensity (K/L) of production. The decline in the capital intensity of production will reduce the productivity of labour. The causality in this relationship runs unambiguously from relative factor prices w/r to the choice of technique. The argument can also be stated in growth rates, that is, a fall in the growth rate of (w/r) will reduce the growth rate of K/L and hence the growth of labour productivity.
2. *Vintage*: The productivity of labour depends not only on capital intensity K/L but also on the productivity of capital, Y/K. The productivity of K depends on the age (or vintage) of K; more recent vintages are assumed to be more productive than older ones. If (the growth rate of) the real wage w/p rises it becomes efficient for firms to invest in new (more productive) vintages of capital, thus raising labour productivity to the higher w/p.
3. According to the theory of *induced technological change*, a higher relative wage rate increases the labour-saving bias of newly developed technology (Hicks, 1932; Kennedy, 1964; van Schaik and van de Klundert, 1978; Funk, 2002).
4. In *endogenous growth* theory a profit-maximising capitalist's decision to invest in R&D, which is assumed to lower labour costs by raising labour productivity, is taken to depend on the share of wages in total costs: the higher the wage share, the more profitable it becomes to devote resources to increasing the productivity of labour (Foley and Michl, 1999).
5. Innovative activity and labour productivity growth are stimulated by buoyant demand prospects—giving rise to *demand-driven models of techn(olog)ical change* (Verdoorn, 1949; Schmookler, 1966; Geroski and Walters, 1995). Wage restraint may thus harm innovation to the extent that it leads to a loss of effective demand.

A common element in all these theories is that wage growth—through various channels—stimulates (process) innovation and labour productivity. Yet, in the literature on the Dutch 'employment miracle', the above effects of wage moderation have received only scant attention, while some authors explicitly deny the possibility that such effects may have operated (van der Wiel, 1999; Fase and Tieman, 2001).

3. The Dutch productivity crisis: stylised facts

In our view, the following three stylised facts are supported by robust empirical evidence and hence are not controversial.

Stylised fact 1: Since 1984, the Dutch economy is facing a serious productivity growth problem: (a) recent Dutch labour productivity growth is much below the growth rate achieved before 1980; (b) recent Dutch labour productivity growth is low compared to the productivity growth rates achieved by other OECD countries; and (c) labour productivity growth slowed down in all sectors of the economy and cannot be attributed to problems in specific (service) sectors.

Table 1
Gross Domestic Product per hour, The Netherlands 1950–2000 (average annual growth rates)

Authors' estimates[a]	
1970–1980	3.61
1984–1997	0.76
1996–2000	1.12
Wolff (1996)	
1950–1960	4.08
1960–1973	5.12
1973–1979	3.40
1979–1989	1.73
van der Wiel (1999)[b]	
1974–1979	3.6
1980–1985	3.2
1986–1990	2.0
1991–1995	1.1
van Ark (2000)	
1960–1973	4.5
1973–1987	2.9
1987–1998	1.7
1995–1998	1.7

[a] Authors' estimates based on data from the National Accounts of The Netherlands. Estimates for 1996–2000 are based on the New Series of the national accounts; the estimates for the other periods are based on the Old Series.

[b] Productivity growth rates by van der Wiel (1999) are for the so-called market sector, i.e. aggregate gross value added minus gross value added in mining and quarrying, operation of real estate, and medical and other non-market services.

Table 1 presents—for different historical periods—our estimates of Dutch labour productivity and compares these with recent estimates by Wolff (1996), van der Wiel (1999) and van Ark (2000). Although the various estimates differ in quantitative terms, they unequivocally show the following trends:

1. since the beginning of the 1970s, Dutch labour productivity growth slowed down significantly (from 4.5–5% during 1960–1973 to 3.4–3.6% during the 1970s); and
2. it declined further from the mid-1980s onwards—to only about 0.8–1.7% during the 1990s.

The first period of Dutch productivity growth decline (the 1970s) was part of a larger process of productivity growth slowdown across the OECD area, as can be seen from Table 2. However, the post-1984 slowdown of Dutch productivity growth is exceptional: as our estimates in Table 2 show, the percentage decline in the productivity growth rate during 1984–1995 compared to that achieved during the 1970s was higher (at −73%) for The Netherlands than for any other country in our sample as well as substantially higher than the EU average. Hence, whereas "the first slowdown around 1973 was generally a global phenomenon, the second slowdown is definitively not" (van der Wiel, 1999, p. 13). Likewise, van Ark(2000, p. 89) concludes that The Netherlands have experienced a substantive relative productivity growth slowdown, which is even more remarkable in view of the fact that "it

Table 2
Gross Domestic Product per hour (average annual growth rates)[a]

	B (1)	France (2)	G[b] (3)	Italy (4)	NL (5)	UK (6)	**EU-14** (7)	USA (8)	Japan (9)
1960–1973	5.5	5.0	5.2	7.8	4.5	3.8	**5.5**	2.7	8.4
1970–1980	4.8	4.0	4.0	4.5	3.3	2.8	**3.7**	1.6	4.8
1984–1995	2.0	2.1	2.0	2.8	0.9	2.0	**2.2**	1.3	2.8
1995–2000	2.1	1.1	1.8	1.3	0.9	1.6		1.8	2.0
Change 1970–1980/ 1984–1995 (%)	−58	−48	−50	−39	−73	−28	−40	−18	−41

[a] Estimates for the period 1960–1973 are from van Ark (2000). Estimates for the other periods are based on Groningen Growth and Development Centre data, in national currency, at 1996 prices (http://www.eco.rug.nl/ggdc/). Differences between authors' estimates in Tables 1 and 2 are due to differences between the data sources in their estimation of GDP at factor cost.

[b] Estimates in column (3) are for West Germany, except for the periods 1991–1995 and 1995–2000 which are estimates for whole of Germany.

had by far the biggest acceleration of real GDP growth which was not materialised in faster labour productivity growth."

It has proven very difficult to empirically "explain" the recent Dutch productivity growth slowdown. One, often used, explanation holds that it is due to the decline in the potential of the (lagging) Dutch economy to technologically "catch-up" with the world's leading economy (in this case, the US). The idea is that the larger is the technological gap (reflected by the ratio of relative TFP levels), the higher the potential of the lagging economy to increase its pace of technological progress by means of capital goods imports, embodying the latest technology, and by the cross-border transfer of knowledge, and the higher should be its rate of TFP growth (see Wolff, 1996). As the TFP gap between the US and The Netherlands declined during 1960–1980, the pace of technological progress could no longer be increased the easy way (via imports and knowledge transfers) but only the hard way (via domestic research efforts); accordingly, the pace of technological progress in The Netherlands declined. The post-1984 decline in Dutch TFP growth *relative to* other OECD countries is then explained as follows. Since the Dutch economy had experienced above-OECD-average TFP growth during 1960–1979, the end of the process of technological catching up was felt particularly hard in this country, thus explaining the above-average decline in productivity growth after 1984. But empirical estimates by Maddison (1996) and Wolff (1996) indicate that the catch-up effect has been a relatively minor factor, accounting for only 6.5–10.3% of the Dutch productivity growth decline between 1960–1973 and 1973–1992/1989, respectively. Econometric estimates by van de Klundert and van Schaik (1996) even indicate that the catch-up variable is statistically not significant during the post-1973 period. Moreover, other EU countries such as Germany and France, which experienced a similar decline in catch-up potential during 1960–1980 as The Netherlands, did not experience a similar slowdown in productivity (and TFP) growth after 1984 as did the Dutch economy.

A second explanation of the slowdown of Dutch productivity growth holds that it is not due to a general across-the-board decline in productivity growth, but rather the result of (i) a shift in sectoral employment shares from (high-productivity) manufacturing to (low-productivity) services sectors, and/or (ii) problems in specific sectors (van der Wiel, 1999, p. 12). Neither of these two claims, however, are sustained by the data. As Table 3 shows, the decline in labour productivity growth after 1984 (by 55% on average) has occurred across the board and cannot be attributed to a single (or a few) sectors. The two claims can also be tested more formally by using a shift-share decomposition analysis, showing how much the various sectors have contributed to the overall productivity decline. To this end, the aggregate productivity growth rate is expressed as a weighted average of sectoral productivity growth rates—the weights being the share of sector i in aggregate employment:

$$\left[\frac{\dot{Y}}{L}\right] = \sum_{i=1}^{n} \left[\frac{\dot{Y}_i}{L_i}\right]\left[\frac{L_i}{L}\right] = \sum_{i=1}^{n} \dot{P}_i S_i,$$

where Y and L represent aggregate output and employment, Y_i and L_i represent output and employment by sector, P_i represents sectoral labour productivity (Y_i/L_i) and S_i is the sectoral employment share (L_i/L). The discrete-time first difference expansion of this equation can be decomposed into *three* components as follows:

$$\left[\frac{\dot{Y}}{L}\right]^t - \left[\frac{\dot{Y}}{L}\right]^0 = \sum_{i=1}^{n}(\dot{P}_i^t - \dot{P}_i^0)S_i^0 + \sum_{i=1}^{n} \dot{P}_i^0(S_i^t - S_i^0) + \sum_{i=1}^{n}(\dot{P}_i^t - \dot{P}_i^0)(S_i^t - S_i^0).$$

The *first* term on the right-hand side represents the impact on the aggregate productivity growth rate of changes in productivity growth rates within sectors; this effect is called the intra-sectoral productivity growth effect. The *second* term represents the impact on aggregate productivity growth of changes in sectoral employment shares. This employment share shift effect is positive when labour moves from sectors with below-average (base-period) productivity growth rates into sectors with above-average (base-period) productivity growth rates. The *third* term is the so-called interaction effect, which represents the joint effect of changes in employment shares and changes in sectoral productivity growth rates. The interaction effect will be positive when employment shares and productivity growth rates increase (decrease) in the same sectors. It will be negative when (a) employment shares of sectors in which productivity growth rises, decline; or (b) employment shares of sectors in which productivity growth declines, rises. We applied this shift-share analysis to the decline in Dutch productivity growth between 1970–1980 and 1984–1997. The results, presented in Table 3, are as follows.

First, changes in sectoral employment shares (from high- to low-productivity growth sectors) contributed 17.5% to the post-1984 overall productivity growth decline. The major part of this 17.5% contribution is due to a fall in the employment share of manufacturing, where initial productivity growth rates were relatively high (5.16% per annum on average). Second, the interaction effect is small and negative. The sum of the employment share shift effect and the interaction effect is generally interpreted as the total effect of structural change on aggregate labour productivity growth (Maddison, 1996). The impact on aggregate productivity growth of the structural change effect is limited, explaining only 10.2 (= 17.5 − 7.3)% of the slowdown. Third, intra-sectoral productivity growth declines explain 89.7% of the aggregate productivity growth decline. What strikes is the relatively large impact of the decline in productivity growth in manufacturing and mining. Note that the contribution of manufacturing and mining to the aggregate slowdown (explaining 37%

Table 3
Sectoral labour productivity growth: The Netherlands 1970–1997[a] (average annual growth rates)

	Agriculture	Mining and manufacturing	EGW[b]	Construction	Trade	Transport	Other services	Total
1970–1980	6.05	5.16	5.46	0.71	3.06	3.04	1.19	3.00
1984–1997	4.13	2.84	2.90	0.06	1.30	2.67	0.54	1.34
Change between 1970–1980 and 1984–1997	−31.7	−45.1	−47.0	−91.0	−57.7	−12.3	−54.6	−55.4
Shift-share analysis: percentage contributions to the post-1984 aggregate productivity decline								
Intra-sectoral productivity effect	7.9	36.8	1.6	4.5	22.7	1.6	14.7	89.7
Employment share shift effect	4.6	20.9	0.2	1.3	−1.7	−0.8	−7.0	17.5
Interaction effect	−1.5	−9.4	−0.1	−1.2	1.0	0.1	3.8	−7.3
Total effect	11.0	48.3	1.7	4.6	22.0	0.9	11.5	100.0
Percentage share in aggregate employment								
1970–1980	6.1	23.6	9.1	10.3	19.2	6.4	33.5	100.0
1984–1997	5.0	17.6	0.9	7.6	20.0	6.8	42.2	100.0
Percentage share in real GDP at factor cost								
1984–1997	3.1	20.2	1.8	5.9	15.0	7.3	46.8	100.0

[a] *Source*: authors' estimates based on data from *National Accounts of The Netherlands.*
[b] Electricity, gas and water supply.

of the total) far exceeds the share of this sector in either employment or GDP. Manufacturing and mining contribute about as much to the overall productivity growth decline as the services sectors (39% for trade, transport and other services combined), despite the latters' much larger share in employment (more than twice that of manufacturing in the 1970s).

The above findings provide little support for the view that the post-1984 slowdown of Dutch productivity growth is due to a rise in sectors which are low-productive 'by nature', or to problems in a few isolated segments of the economy. Similar conclusions are reached by van Ark and de Haan (1999) and van Schaik (2002). Accordingly, we must conclude that the Dutch economy entered a general productivity growth crisis after 1984.

> *Stylised fact* 2: The deterioration in productivity growth coincides in time with the policy of voluntary wage restraint: nominal and real wage growth in the period 1984–2000 are significantly below the wage growth realised during 1970–1980. As a result, the growth rate of relative factor prices (i.e. the wage–capital price ratio) has declined.

In 1982, Dutch trade unions agreed to moderate their wage demands. As Table 4 shows, nominal wage growth, which amounted to more than 12% per annum in the 1970s, was reduced to only 1.6% per year during 1984–1997; real wage growth declined from 4.4% per year in the first period to only 0.3% per year during the second period. The growth rates of capital stock prices also declined after 1984, but much less than the growth rate of wages. As a result, as shown in Table 4, the growth rate of the price of labour vis a vis the capital price came down from 6.5% per year during the 1970s to 0.3% during 1984–1997. This large decline in the growth rate of the relative price of labour is the essential stylised fact in our argument.

In an international context, the post-1984 Dutch wage moderation has been exceptional. This can be seen from Table 5, in which appear the growth rates of relative nominal wages for a sample of OECD countries. The relative wage of country i, w_i^{R}, is defined as the ratio of its nominal wage w_i to the average wage rate w^{A} of all countries in the sample. The average (decadal) export market share is used as the weighting factor. Relative wage *growth* is then defined as: $\dot{w}_i^{\mathrm{R}} = \dot{w}_i - \dot{w}^{\mathrm{A}}$. If $\dot{w}_i^{\mathrm{R}} < 0$, nominal wage growth in country i has been lower than the OECD-sample average. Table 5 shows that in the 1980s Dutch relative

Table 4
Nominal and real factor prices, The Netherlands 1975–2000[a] (average annual growth rates)

	Value added price (= GDP deflator)	Compensation of employees (nominal) (w)	Compensation of employees (real) (w/p)	Price of capital stock (nominal) (r)	Price of capital stock (real) (r/p)	Input price ratio (w/r)
1970–1980	7.4	12.2	4.4	5.5	−1.8	6.5
1984–1997	1.4	1.6	0.3	1.4	0.1	0.3
New series						
1995–2000	1.8	3.4	1.5	−0.3	−2.1	3.8

[a] *Source*: authors' estimates on the basis of data from the CBS, *National Accounts of The Netherlands*. Estimates for the period 1995–2000 are based on the new series of the *National Accounts*; all other estimates are based on the old series.

Table 5
Relative nominal wage growth: OECD countries 1961–2000[a] (average annual growth rates)

	B (1)	France (2)	G[b] (3)	Italy (4)	NL (5)	UK (6)	USA (7)	Japan (8)
1961–1970	−0.3	1.3	0.4	2.5	2.4	−1.2	−3.0	5.3
1971–1980	0.6	2.2	−3.3	6.8	−0.7	4.4	−3.5	1.5
1981–1990	−0.6	1.5	−2.1	6.1	−3.5	3.0	−0.3	−1.7
1991–2000	0.0	−0.5	0.4	0.7	−0.3	1.5	0.3	−2.2

[a] *Source*: authors' estimates based on data from European Commission (2000) *European Economy* 69.
[b] The estimates in column (3) are for West Germany, except for the period 1991–2000, which is an estimate for united Germany.

wage growth was significantly lower than that of any other OECD economy and it remained below the sample average in the 1990s.

Stylised fact 3: The Dutch productivity crisis is reflected in a sharp increase in the labour intensity of Dutch economic growth. The aggregate employment elasticity (defined as the percentage change in employment growth associated with 1% of real GDP growth) increased sharply after 1984. Moreover, employment elasticities are significantly higher in The Netherlands than in other OECD countries.

The employment intensity (measured in hours) of Dutch economic growth has substantially increased after 1984. As shown in Table 6, the employment intensity of Dutch GDP growth declined from about 0.1 during the 1950s and 1960s to −0.05 during the 1970s, but it then suddenly increased dramatically to about 0.6 during 1980–2000. In terms of employment elasticities, the 1980s and 1990s represent a structural break with the past, when GDP growth was achieved with only a small increase or even a decrease in hours worked. A similar structural break did not occur in most other OECD countries, in which the employment elasticities continued to be low or negative. The Dutch experience contrasts particularly sharply with that of Germany, where the employment elasticity became even more negative during the 1990s. German GDP increased, while hours worked declined, whereas Dutch GDP increased by working more hours.

Table 6
Employment elasticities, major OECD countries 1950–2000, 1996 prices[a] (average annual growth rates)

	B (1)	France (2)	G[b] (3)	Italy (4)	NL (5)	UK (6)	**EU-14** (7)	USA (8)	Japan (9)
1950–1960	−0.05	−0.13	0.19	0.48	0.10	0.31	**0.07**	−0.03	0.34
1960–1973	−0.11	0.06	−0.22	−0.26	0.07	−0.16	**−0.09**	0.39	0.13
1973–1980	−0.63	−0.34	−0.47	0.07	−0.05	−1.15	**−0.15**	0.60	0.19
1981–1990	−0.22	−0.24	−0.19	0.09	0.57	0.18	**0.12**	0.55	0.25
1991–2000	−0.12	0.26	−0.44	−0.27	0.61	0.03	**0.13**	0.51	−0.35
1991–1995	−0.50	−0.38	−1.00	−1.44	0.49	−0.57	**−0.47**	0.52	−0.26
1996–2000	0.09	0.54	0.07	0.54	0.68	0.37	**0.41**	0.50	−0.44

[a] *Source*: computed as the difference between GDP growth and hourly labour productivity growth, divided by GDP growth.
[b] Rows 1–4: West Germany; row 5: United Germany.

The above stylised facts are empirically robust and hence uncontroversial. It will also be accepted that (some of) the stylised facts may be interrelated, e.g. the increase in the labour intensity of economic growth is related to the productivity slowdown. The controversy resides in our specific claim—in turn based on various theoretical considerations—that wage moderation has contributed to the productivity crisis. In the remainder of this paper, we will empirically substantiate our (theoretical) claim within a (standard and expanded) growth-accounting framework.

4. The relative price of labour and K/L substitution

An important channel through which wage moderation may affect labour productivity growth is substitution of labour for capital. To evaluate the empirical importance of this neo-classical substitution effect, we use the following CES production function (homogeneous of degree h):

$$Y = \gamma[\delta L^{-\rho} + (1-\delta)K^{-\rho}]^{-(h/\rho)}, \tag{1}$$

where $1 < \rho < \infty;\ \rho \neq 0;\ 0 < \delta < 1;\ \gamma > 0;\ h > 0$; and

$$\sigma = \frac{\mathrm{d}(K/L)/(K/L)}{\mathrm{d}(w/r)/(w/r)} = \frac{1}{1+\rho}.$$

Y is real GDP, K is the capital stock, L is employment (number of hours worked), w is the nominal wage rate, r is the nominal rental price of the capital stock; ρ measures the substitutability of labour and capital, σ is the substitution elasticity, γ is the so-called efficiency parameter and δ is the distribution parameter. h is the scale parameter. Note that if $h = 1$, the production function exhibits constant returns to scale; if $h > 1$ ($h < 1$), the production function exhibits increasing (decreasing) returns to scale. Assuming profit maximisation, and using the first-order conditions $p(\mathrm{d}Y/\mathrm{d}L) = w$ and $p(\mathrm{d}Y/\mathrm{d}K) = r$, the following factor demand equations can be derived:

$$L = \left[\frac{h\delta}{\gamma^{\rho/h}}\right]^{\sigma}\left[\frac{w}{p}\right]^{-\sigma} Y^{(h+\rho)/(h(\rho+1))}, \tag{2}$$

$$K = \left[\frac{h(1-\delta)}{\gamma^{\rho/h}}\right]^{\sigma}\left[\frac{r}{p}\right]^{-\sigma} Y^{(h+\rho)/(h(\rho+1))}, \tag{3}$$

where p is the GDP deflator. Dividing Eq. (3) by Eq. (2) gives us the following expression for the capital–labour ratio or capital intensity:

$$\frac{K}{L} = \left[\frac{\delta}{(1-\delta)}\right]^{-\sigma}\left[\frac{w}{r}\right]^{\sigma}, \tag{4}$$

which shows that the K/L ratio depends on the price of labour relative to the price of capital, the substitution elasticity σ and the distribution parameter δ. We express (4) in terms of growth rates by totally differentiating (4), dividing through by K/L, and re-arranging:

$$\left[\frac{\dot{K}}{L}\right] = \sigma\left[\frac{\dot{w}}{r}\right]. \tag{5}$$

The growth rate of capital intensity thus depends on the growth rate of the relative factor price ratio; the size of the impact depends on σ. A decline in the growth rate of capital intensity, in turn, will have a negative impact on labour productivity growth. To make this effect explicit, we rewrite Eq. (1) as a function of labour productivity Y/L as follows:

$$\frac{Y}{L} = \gamma^{1/h}\left[\delta + (1-\delta)\left[\frac{K}{L}\right]^{-\rho}\right]^{-(1/\rho)} Y^{(h-1)/h}. \tag{6}$$

It is straightforward to see that $\mathrm{d}(Y/L)/\mathrm{d}(K/L) > 0$, i.e. a decline in capital intensity reduces the level of labour productivity. To empirically assess the impact on labour productivity growth of a decline in the growth rate of the labour–capital price ratio, we express Eq. (6) in growth rates as follows:

$$\left[\frac{\dot{Y}}{L}\right] = \frac{1}{h}\dot{\gamma} + \left[\frac{(1-\delta)(K/L)^{-\rho}}{\delta + (1-\delta)(K/L)^{-\rho}}\right]\left[\frac{\dot{K}}{L}\right] + \left[\frac{h-1}{h}\right]\dot{Y}, \tag{7}$$

and substituting (5) into (7) gives:

$$\left[\frac{\dot{Y}}{L}\right] = \frac{1}{h}\dot{\gamma} + \sigma\left[\frac{(1-\delta)(K/L)^{-\rho}}{\delta + (1-\delta)(K/L)^{-\rho}}\right]\left[\frac{\dot{w}}{r}\right] + \left[\frac{h-1}{h}\right]\dot{Y}. \tag{8}$$

Eq. (8) gives the relationship between, on the one hand, capital intensity and income and, on the other hand, labour productivity in its general form. Most empirical (growth-accounting) analyses of labour productivity growth, however, employ a constant-returns-to-scale production function framework. Hence, for the sake of comparison, we will initially assume that $h = 1$; Eq. (8) then reduces to:

$$\left[\frac{\dot{Y}}{L}\right] = \dot{\gamma} + \sigma\left[\frac{(1-\delta)(K/L)^{-\rho}}{\delta + (1-\delta)(K/L)^{-\rho}}\right]\left[\frac{\dot{w}}{r}\right]. \tag{9}$$

As Eq. (9) shows, labour productivity growth depends positively on the following two factors:

1. the growth rate of the efficiency parameter γ which—within a growth-accounting framework—represents so-called total factor productivity (TFP) growth; and
2. the growth rate of the labour–capital price ratio, representing the substitution effect. The impact on labour productivity growth of a change in the growth rate of relative factor prices depends on σ and on the CES share of capital in output.[1]

Eq. (9) is used to empirically assess the impact of wage moderation on post-1984 labour productivity growth in The Netherlands. In order to do so, labour productivity growth is

[1] The share of capital in output is given by:

$$\left[\frac{(1-\delta)(K/L)^{-\rho}}{\delta + (1-\delta)(K/L)^{-\rho}}\right].$$

Multiplying this expression by $[L^{-\rho}/L^{-\rho}]$ gives a more straighforward result:

$$\left[\frac{(1-\delta)K^{-\rho}}{\delta L^{-\rho} + (1-\delta)K^{-\rho}}\right].$$

Table 7
Estimates of the labour–capital substitution elasticity, The Netherlands[a]

Author(s)	Estimation period	Estimated value	Remarks
Broer et al. (2000)	1966–1995	0.35	
CPB (1997)	1969–1993	0.00–0.15	0.00 for the sheltered sector; 0.15 for the exposed sector
Draper and Manders (1997)	1969–1993	0.03–0.06	0.03 for the sheltered sector; 0.06 for the exposed sector
Draper and Huizinga (2000)	1969–1998	0.29	
Fase et al. (1992)		0.07	Morkmon model
Fase and Winder (1999)	1956–1993	0.02–0.54	0.02 for services; 0.54 for manufacturing
Jacobs and Sterken (1995)	1973–1992	0.25	IBS-CCSO quarterly model
Kuipers et al. (1990)	1973–1992	0.25	CCSO annual model
Layard et al. (1991)		0.13–0.24	Implicit estimates derived in Rowthorn (1999)
Magnus (1979)	1950–1976	0.69–0.88	Substitution elasticity is declining over time

[a] *Source*: authors' compilation.

decomposed into the contribution of TFP growth and capital deepening for the pre-wage moderation period 1970–1980 and the wage moderation period 1984–1997. For this exercise, empirical estimates are required for L, K, the growth rate of (w/r), σ, and δ. Data sources and the construction of the estimates are described in Appendix A for all these variables except σ. Because of its central importance to our argument, our estimation of the (aggregate) substitution elasticity σ is discussed here in more detail.

Empirical evidence for The Netherlands—summarised in Table 7—suggests that the elasticity of capital–labour substitution is rather low, i.e. in the range of 0.2–0.4. The average value of σ in Table 7 is about 0.3. Estimates by authors associated with the CPB Netherlands Bureau for Economic Policy Analysis suggest that σ is about 0.29–0.35 (Broer et al., 2000; Draper and Huizinga, 2000), while the CPB's JADE model uses much lower values (CPB, 1997; Draper and Manders, 1997). In the MORKMON model, developed and operated at the Dutch central bank σ has a value of only 0.07 (Fase et al., 1992). Other (university) models for The Netherlands (Kuipers et al., 1990; Jacobs and Sterken, 1995) incorporate an estimated σ of 0.25. The result of our estimation of σ for the period 1970–1997, based on Eq. (5), appears in Table 8. Because there was significant autocorrelation in the data, the equation (in logarithms) was estimated by the Cochrane–Orcutt AR(1) method. We find an aggregate (statistically significant) substitution elasticity of 0.27, which is close to the average of the elasticities reported in Table 7. Hence, the empirical evidence of low substitution possibilities appears to be robust, both across studies and over time. Accordingly, in our growth accounting analysis (below), we shall assume $\sigma = 0.3$.

Table 9 presents the results of a growth accounting exercise based on Eq. (9). Table 9 shows that for the total economy, growth in value added per labour year slowed down from about 3.6% during 1970–1980 (the pre-wage moderation period) to 0.8% between 1984 and 1997 (the wage moderation period). This labour productivity growth slowdown is due to both a slowdown of TFP growth and a slower rise in capital intensity during the second

Table 8
Results of regression analysis[a b]

Equation	Dependent variable	Constant	Independent variable	Independent variable	d.f.	$\bar{R}^2$	F	DW
Eq. (5)	$\log\left[\frac{K}{L}\right]$		$\sigma \log\left[\frac{w}{r}\right]$ 0.27** (36.69)		27	0.98	1346.1	1.46
Eq. (10)	$\dot{\gamma}$	$\dot{\alpha}_1$ −0.74 (1.09)	$\beta_1\left[\frac{\dot{K}}{L}\right]$ 0.69** (3.86)		26	0.34	14.9	1.92
Eq. (15)	$\left[\frac{\dot{Y}}{L}\right]$	$\gamma_{\mathrm{dis}} + \Pi\psi$ −0.18 (0.35)	$\Pi\left[\frac{\dot{K}}{L}\right]$ 0.83** (6.56)	$\Pi\psi\Delta\bar{\alpha}$ −2.93* (1.88)	25	0.70	31.8	1.73
Eq. (7)	$\left[\frac{\dot{Y}}{L}\right]$	$\left[\frac{1}{h}\right]\dot{\gamma}$ −2.31** (4.60)	$\left[\frac{(1-\delta)(K/L)^{-\rho}}{\delta + (1-\delta)(K/L)^{-\rho}}\right]\left[\frac{\dot{K}}{L}\right]$ 0.85** (9.07)	$\left[\frac{h-1}{h}\right]\dot{Y}$ 0.70** (4.71)	25	0.82	60.9	1.52

[a] Period: 1970–1997.
[b] *Note*: (**) significance level 0.01; (*) significance level 0.05. Absolute t-values are given in parentheses; d.f.: degrees of freedom; DW: Durbin–Watson statistic.

Table 9
Accounting for the growth of labour productivity, The Netherlands 1970–2000[a]

Period	Labour productivity growth $[\dot{Y}/L]$ (1)	Percent point contribution[b c]		Growth of w/r ratio[d] $[\dot{w}/r]$ (4)	Growth of K/L ratio[e] $[\dot{K}L]$ (5)
		TFP growth $\dot{\gamma}$ (2)	Growth of w/r $[\dot{w}/r]$ (3)		
1970–1980	3.61	1.58 (43.7)	2.03 (56.3)	6.5	1.9
1984–1997	0.76	0.67 (87.7)	0.09 (12.3)	0.3	0.1
1995–2000	1.12	−0.09 (−8.2)	1.21 (108.2)	3.8	1.1

Percentage of total change in annual labour productivity growth between 1970–1980 and 1984–1997 explained by:

	$[\dot{Y}/L]$	$[\dot{\gamma}]$	$[\dot{w}/r]$
	100.0	31.9	68.1

[a] *Source*: authors' estimates.
[b] The contributions of TFP growth (column 2) and (w/r) growth (column 3) to labour productivity growth (column 1) are calculated using Eq. (9), assuming $\sigma = 0.3$.
[c] Figures in parentheses are percent shares in labour productivity growth.
[d] Actual (observed) growth of w/r ratio (p.m.).
[e] Actual (observed) growth of K/L ratio (p.m.).

period. Out of the 2.85 percentage points decline in productivity growth during 1984–1997 as compared to the 1970s, about 31.9% can be attributed to a decline in TFP growth. The remaining 68.1% is due to a slowdown in the growth rate of capital intensity, which in turn is caused by the moderation of nominal wage growth vis-à-vis the growth of the capital price. As shown in Table 9, the growth rate of K/L declined from 1.9% per annum during the 1970s to only 0.1% per year during 1984–1997, following the decline in the growth rate of relative factor prices from 6.5% to only 0.3% per year over the same periods.

To bring out more clearly the importance of the productivity growth reducing effect of wage moderation, we use Eq. (9) for counterfactual analysis, assuming that the rate of TFP growth is exogenously given. With $\sigma = 0.3$ and using the average value of δ for the period 1984–1997, we ask what the growth rate of labour productivity would have been if the growth rate of relative factor prices had been higher. It follows that an annual growth rate of the wage–capital price ratio of 3% (rather than the actual 0.3%) would have doubled productivity growth to 1.52% per year. This counterfactual underscores the importance of wage moderation—through its impact on the growth rate of relative factor prices—for capital intensity growth and hence labour productivity growth.

How do our results—obtained so far—compare to the results of other studies? To answer this question, Table 10 presents the results of recent growth accounting analyses by Wolff (1996), van Ark and de Haan (1999) and van der Wiel (1999). A comparison of Table 10 with our findings in Table 9 suggests the following. First, the declines in labour productivity growth, TFP growth and capital intensity growth after the mid-1980s reported in other sources (presented in Table 10) are as pronounced as the reductions found by us—particularly when we compare post-1984 growth rates to those of the 1960s. Second, implicit in these other studies, the decline in the growth rate of relative factor prices has

Table 10
Accounting for the growth of Dutch labour productivity: alternative estimates[a]

Period	Labour productivity growth $[\dot{Y}/L]$ (1)	Percent point contribution		Growth of w/r ratio $[\dot{w}/r]$ (4)	Growth of K/L ratio $[\dot{K}/L]$ (5)
		TFP growth $\dot{\gamma}$ (2)	Growth of w/r $[\dot{w}/r]$ (3)		
Wolff (1996)[b]					
1960–1973	5.12	3.01 (58.8)	2.11 (41.2)	5.23	5.23
1973–1979	3.40	1.76 (51.8)	1.64 (48.2)	4.05	4.05
1979–1989	1.73	0.57 (32.9)	1.16 (67.1)	2.90	2.90
van Ark and de Haan (1999)[c]					
1973–1987	2.8	1.7 (60.7)	1.1 (39.3)	4.0	4.0
1987–1996	1.7	1.1 (64.7)	0.6 (35.3)	1.8	1.8
van der Wiel (1999)[d]					
1974–1979	3.6	2.5 (69.4)	1.1 (30.6)	8.9	3.1
1980–1985	3.2	2.4 (75.0)	0.8 (25.0)	6.0	2.1
1986–1990	2.0	1.7 (85.0)	0.3 (15.0)	2.0	0.7
1991–1995	1.1	0.7 (63.3)	0.4 (36.4)	2.9	1.0

[a] Figures in parentheses are percentage shares in labour productivity growth.

[b] Figures in columns (1), (2) and (5) are taken from Table 1 in Wolff (1996, p. 1241). TFP growth is estimated on the basis of a Cobb–Douglas production function, using average factor shares for each current year and the previous year as weights. Labour productivity is defined as value added per hour worked. By definition, $\text{column}(3) = \text{column}(1) - \text{column}(2)$. Figures in column (4) were estimated on the basis of our Eq. (4), using figures in column (5) and assuming $\sigma = 1.0$ (Cobb–Douglas).

[c] Figures in columns (1), (2) and (5) are taken from Table 7.8 in van Ark and de Haan (1999, p. 174). For estimation method used, see footnote 1.

[d] Figures in columns (1), (2) and (3) are from Table 3.1 in Wiel (1999, p. 17). TFP growth is estimated on the basis of a translog production function, using average factor shares for each current year and the previous year as weights. Labour productivity is defined as gross value added per hour worked. These figures refer to the market sector (i.e. all sectors excluding mining and quarrying, operation of real estate, and medical and other non-market services). Capital intensity growth (column (5)) was estimated using Wiel (1999, p. 8)'s Eq. (4), according to which labour productivity growth $[\dot{Y}/L] = \dot{\gamma} + \theta[\dot{K}/L]$, where θ is the average value share of capital. Period-wise estimates of θ were derived based on national accounts data. Figures in column (4) were estimated on the basis of our Eq. (5), using figures in column (5) and assuming $\sigma = 0.35$.

led—via capital–labour substitution alone—to a substantial slowdown of capital intensity growth, to which in turn about 40–50% of the post-1984 reduction in the growth rate of labour productivity can be attributed. On the basis of the evidence so far, it therefore seems safe to conclude that Dutch labour productivity growth has been negatively influenced by the policy of voluntary wage restraint, which resulted in a substantial decline in the w/r growth rate. If the substitution mechanism operates symmetrically upwards and downwards, it follows that productivity growth would have deteriorated less if the growth rate of relative factor prices had been higher.

Furthermore, all studies do confirm (see Tables 9 and 10) the large contribution of TFP growth to Dutch labour productivity growth. On average (i.e. across all studies and time periods reported in Tables 9 and 10), TFP growth contributed 62% to Dutch labour productivity growth. It is important that this TFP growth be explained. After all, a theory of economic growth that explains about 62% of productivity growth by an unexplained residual (which is what "growth of total factor productivity" really is) is—in Nelson (1964, p. 580)'s words—"not much of a theory".

5. Explaining TFP growth: extended growth accounting

There are various ways to probe into the nature of TFP growth $\dot{\gamma}$. We will follow three approaches. The first is to endogenise (or explain) TFP growth by directly investigating the positive interactions between capital accumulation and TFP growth (the new growth theory approach). The second is to focus on the productivity-growth enhancing effects of improvements in the quality of the capital stock (the vintage approach). Our third approach is to abandon the assumption of constant returns to scale (underlying the growth accounting framework used so far), assuming increasing returns to scale instead. Each of these approaches further enriches our understanding of the 1970–2000 Dutch productivity growth record.

5.1. A new growth theory approach

New (or endogenous) growth theory (e.g. Foley and Michl (1999, pp. 286–298)) can be regarded as an attempt to provide theoretically sensible explanations of TFP growth. The general implication of new growth theory is that there exist positive interactions between capital accumulation and technological advance (as reflected by TFP growth). The literature suggests several avenues through which capital accumulation and TFP growth interact (see Wolff (1991, p. 566) for an overview), of which we would like to mention the following ones.

- *Vintage effect*: New capital may be more productive than old capital per (constant) Euro of expenditure (the 'vintage effect'). Hence, if the capital stock data do not correct for vintage effects, then a positive correlation should be observed between the growth rate of TFP and the growth rate of capital (per worker) (Wolff, 1991; Nelson, 1964).
- '*Learning by investing*': The introduction of new capital enables the firm to simultaneously learn to produce more efficiently—leading to better organisation, management etc. Thus, productivity-enhancing knowledge creation is a side effect of investment ('learning by doing').
- *Anticipation of higher profits*: Potential technological advance may stimulate capital formation, because the opportunity to modernise equipment promises a high rate of return on investment.
- *Verdoorn effect*: Higher investment growth raises aggregate demand, leading to a generally favourable economic climate for investment and technological change.

In our analysis, it is not possible to distinguish between these various effects, but—following Wolff (1991)—we will refer to them collectively as interaction effects or complementarities between capital accumulation (represented by K/L growth) and TFP growth. We posit the following (positive) relationship between total factor productivity growth and capital intensity growth for The Netherlands:

$$\dot{\gamma} = \alpha_1 + \beta_1 \left[\frac{\dot{K}}{L} \right]. \tag{10}$$

Eq. (10) is a general formulation of the interaction between TFP growth and accumulation. We estimated this equation for The Netherlands. The results, given in Table 8, support our hypothesis that there exist positive and statistically significant complementarities between TFP growth and capital intensity growth.[2] They also conform to Wolff (1991)'s cross-country findings. The finding that capital accumulation per worker is important for TFP growth means that (in line with our central hypothesis) TFP growth is indirectly dependent on w/r growth, as—along the lines of theories of induced technological change (Foley and Michl, 1999, pp. 268–298)—capital intensity growth is dependent on the growth rate of relative factor prices as in our Eq. (5). Substitution of Eq. (5) into (10) and assuming that $\sigma = 0.3$ yields:

$$\dot{\gamma} = \alpha_1 + \beta_1\left[\frac{\dot{K}}{L}\right] = \alpha_1 + \beta_1\sigma\left[\frac{\dot{w}}{r}\right] = -0.74 + 0.21\left[\frac{\dot{w}}{r}\right]. \qquad (11)$$

Using this expression for TFP growth and the earlier decomposition scheme given by Eq. (9), we can now decompose labour productivity growth into:

1. a capital–labour substitution effect, induced by w/r growth;
2. endogenous TFP growth, similarly induced by w/r growth; and
3. exogenous (unexplained) TFP growth.

The sum of effects (1) and (2) represents the total impact of w/r growth on productivity growth.

The results of this decomposition—presented in Table 11—are remarkable. First, in the pre-wage moderation period (1970–1980), a substantial part of TFP growth is explained by relative factor price growth—accounting for 84.8% of total TFP growth. Endogenous TFP growth in turn accounts for 37% of labour productivity growth in this period. If we add to this the productivity-enhancing effect of the relative-factor-price-induced rise in capital intensity growth, we find that relative factor price growth is responsible for 93% of productivity growth. Second, in the wage moderation period (1984–1997), when w/r growth slowed down, the combined contribution of endogenous TFP growth and K/L growth to post-1984 productivity growth declines to 20%. Third, the contribution of endogenous TFP growth—explained by w/r growth—to the labour productivity growth decline between 1970–1980 and 1984–1997 is as much as 45%. If we add to this the productivity-growth-reducing effect of the decline in K/L growth—explained by w/r growth—we find that the decline in the relative factor price is responsible for more than 100% of the productivity slowdown.[3] Each of these findings underscores the crucial importance of relative factor price growth for labour productivity growth. However, while the

[2] We acknowledge that there are other determinants of TFP growth including knowledge and human capital formation and R&D expenditures. But none of these variables can be held responsible for the decline in TFP growth. For example, by all empirical indicators, the stocks of knowledge and human capital have *grown* over time, while TFP growth declined. And Dutch R&D intensity remained fairly constant over time, as shown by time-series data (1964–1990) in Verspagen (1996) and by data (1985–2000) of The Netherlands Central Bureau of Statistics.

[3] The 'over-accounting' is due to the fact that the accounting method is applied on an annual basis to an equation whose parameters have been estimated for a longer period.

Table 11
Labour productivity growth, The Netherlands 1970–2000: extended growth accounting I[a b] (average annual growth rates)

Period	Labour productivity growth (1)	Percent point contribution[c]			
		Unexplained TFP (2)	Endogenous TFP (3)	K/L growth (4)	Sum of columns (3) and (4) (5)
1970–1980	3.61	0.24 (6.6)	1.34 (37.1)	2.03 (56.2)	3.37 (93.3)
1984–1997	0.76	0.61 (80.0)	0.06 (8.1)	0.09 (11.8)	0.15 (19.9)
1995–2000	1.12	−0.87 (−78.0)	0.78 (70.0)	1.21 (108.2)	1.99 (178.0)
		Percentage of total change in annual labour productivity growth between 1970–1980 and 1984–1997 explained by:			
	$[\dot{Y}/L]$	$[\alpha_1]$	$[\beta_1\sigma[\dot{w}/r]]$	$[\dot{w}/r]$	
	100.0	−13.0	44.9	68.1	

[a] *Source*: authors' estimates.
[b] Figures in parentheses are percent shares in labour productivity growth.
[c] The contributions of TFP growth and w/r growth are calculated using Eqs. (9) and (11).

relationship between w/r growth and TFP growth appears to be strong, it remains unsatisfactory if we do not specify explicitly what it means. Two likely channels through which w/r growth influences TFP growth are capital stock age and demand. Each of these channels are investigated explicitly in the next two sections.

5.2. A vintage approach

The essence of the vintage approach is that the capital stock consists of machines of distinct vintage; within the capital stock, machines of more recent vintage are assumed to embody more productive technology. Hence, it is assumed that labour productivity increases (often by a constant proportion) in each new vintage of machine. Machines of vintage v will be kept in use so long as they generate a profit; they will become obsolescent after t years when the output per hour worked (or labour productivity) is less than the labour cost per hour (the real wage rate). This has an important implication, viz., the impact on labour productivity of capital stock (per worker) depends not only on the size of the capital stock but also on its age composition; the older the average age of the capital stock, the lower is its productivity and the smaller will be its contribution to labour productivity growth. Real wage growth will influence the average age of the capital stock because, as $(\dot{w}/p)$ rises, it becomes profitable to invest in new, more productive, machines. Thus, the average age of the capital stock is negatively related to real wage growth, i.e. the higher the growth rate of w/p, the higher will be the investment in new (higher-productivity) vintages. Following this line of argument, real wage moderation, as in The Netherlands post-1984, must have resulted in a rise in the average age of capital, contributing negatively to labour productivity growth. It is important to empirically evaluate the contribution of this vintage effect to the Dutch productivity slowdown, particularly because it has been alleged by the CPB Netherlands Bureau for Economic Policy Analysis that no impact of real wage moderation on the average

age of capital can be found:

> [...] wage moderation has not widely depressed the accumulation of new capital. (van der Wiel (1999), p. 24)

Our capital stock figures are based on data from Maddison (1996). Maddison also gives estimates of the average age of the capital stock for the years 1950, 1973 and 1991. Wolff (1996) uses Maddison's capital stock data and presents estimates of capital's age for the additional years 1960, 1979 and 1989. On the basis of these published figures, we estimated the average age of the capital stock in the remaining years of the period 1950–2000 as follows.

First, for the sub-periods 1950–1960, 1960–1973, 1973–1979, 1979–1989 and 1989–1991, we calculated annual changes in the average age of capital—here denoted by $\Delta\bar{a}$—as a (negative) function of capital stock growth (see Nelson (1964, p. 585)):

$$\Delta\bar{a} = \bar{a}_t - \bar{a}_{t-1} = 1 - \dot{K}(\bar{a}_{t-1} + 1), \tag{12}$$

where $\bar{a}_t$ is the average age of the capital stock in year t. Eq. (12) makes good economic sense. If gross capital formation is zero (i.e. $\dot{K} = 0$), at the end of a year, all old capital will be 1 year older, and since no old capital is being replaced $\Delta\bar{a} = 1$. At the end of a year $\dot{K} = \Delta K/K$ is the ratio of new capital to old capital. The negative effect of new investment on the average age of the capital stock is greater, the greater new investment is relative to the total capital stock, and the greater is the average age of that capital stock.

Second, because the capital stock for the period 1992–2000 was constructed using a perpetual-inventory method (assuming a fixed service life for assets) the average age at time t could be computed as a weighted sum of the investments at each time $(t - v + 1)$ to t, where v is the number of years the asset has been in service and the weight is the age of the investment at time t, divided by the total capital stock at time t (Nelson, 1964; Wolff, 1996). The resulting estimates of the average age of the Dutch capital stock are presented in Table 12.

Table 12
Average age of capital stock, The Netherlands 1970–2000[a]

	Capital stock growth	Average age of capital stock
1970–1980	3.8	11.6
1984–1997	3.5	13.7
1995–2000	5.3	14.5

	1950–1960	1960–1973	1970–1980	1984–1997	1995–2000
Average age of capital stock at the beginning of the period	18.0	15.1	12.1	12.7	14.3
Annualised change in the average age of capital stock	−0.29	−0.29	−0.05	0.13	0.23

[a] Authors' estimates.

It can be seen that the average age of capital during the 1970s is significantly lower than during 1984-1997, following the decline in the capital stock growth rate. These results are in line with estimates by Maddison (1996) and Wolff (1996), which show that:

1. During the 1950s and 1960s (the so-called "golden age of capitalism"), the rate of capital accumulation in The Netherlands was high; consequently, the average age of the Dutch capital stock declined from 18 years in 1950 to 11.3 years in 1973;
2. During the 1970s, which were troubled by two oil crises and the breakdown of the Bretton Woods arrangements (see also van Ark, 2000), the rate of capital accumulation stagnated; consequently, the average age of the Dutch capital stock was more or less constant, varying between 11.3 in 1973 and 11.5 years in 1979;
3. During the 1980s, the average age of the Dutch capital stock rose sharply to 13.9 (14.0) years in 1989 (1991).

The conclusion must be that the average age of the Dutch capital stock has significantly increased after 1984.[4] As discussed above, a decline in real wage growth could be a major cause of this capital stock ageing.[5] We should therefore find a negative relationship between the change in the average age of capital and real wage (w/p) growth. Estimation of this relationship gives the following (statistically significant) result:

$$\Delta\bar{a} = \underset{(3.95)}{0.143}^{**} - \underset{(4.29)}{0.042}^{**}\left[\frac{\dot{w}}{p}\right], \quad \text{d.f.} = 26,\ \bar{R}^2 = 0.39,\ F = 18.44,\ \text{DW} = 2.07.$$

Clearly, the higher the real wage growth, the smaller the annual increase in the average age of the capital stock. Conversely, the more real wage growth is moderated, the larger will be the increase in capital's average age.

It is possible to quantify the negative impact on labour productivity growth of the rise in the average age of capital (Nelson, 1964; Wolff, 1996). In order to do so, we first define J as capital stock measured in 'efficiency units', i.e. a quality-weighted number of machines with new (more productive) machines given greater weight than old (less productive) machines. Next, assuming that advancing technology permits the productivity of new machines to improve by ψ percent per year, J can be written as:

$$J_t = \sum_0^t K_{vt}(1+\psi)^v, \tag{13}$$

where K_{vt} is the amount of capital built in year v (i.e. of vintage v) which is still in use at time t. Expressed in growth rates, this gives:

$$\dot{J} = \dot{K} + \psi - \psi\Delta\bar{a}, \tag{14}$$

[4] This conclusion contradicts van der Wiel (1999)'s claim that the average age of capital in The Netherlands has not changed much after the Wassenaar agreement. However, Van der Wiel's claim appears to be contradicted by his own data. According to Figure 4.2 in Van der Wiel (1999, p. 25), which describes only two subsectors of the Dutch economy (trade and other market services), the average of capital in trade was well below 8 years during the 1970s, but increased to more than 9 years during 1984–1995. Likewise, the average age of capital in other market services increased from about 10–10.5 years during the 1970s to 11–11.5 years during 1984–1995.

[5] Capital stock ageing can be due to other factors, e.g. the rise in energy prices, assuming that capital and energy are complementary.

(for a formal derivation of (14), see Nelson (1964, p. 582)). Using Eq. (14), we can redefine Eq. (7) in terms of capital stock growth measured in efficiency units (assuming that $h = 1$):

$$\left[\frac{\dot{Y}}{L}\right] = [\dot{\gamma}_{\text{dis}} + \Pi\psi] - \Pi\psi\Delta\bar{a} + \Pi\left[\frac{\dot{K}}{L}\right] \quad \text{where } \Pi = \left[\frac{(1-\delta)(K/L)^{-\rho}}{\delta + (1-\delta)(K/L)^{-\rho}}\right]. \tag{15}$$

Eq. (15) includes the (negative) productivity growth impact of an increase in the average age of capital. We estimated Eq. (15) (see Table 8). The goodness of fit is remarkably high for a simple regression of this sort, with an adjusted R^2 of 0.70. Capital-intensity growth is significant at the 1% level and has the expected (positive) sign; the elasticity of labour productivity growth with respect to K/L growth is 0.83. The change in the average age of the capital stock has the expected negative sign and is significant at the 5% level; a 1-year reduction in the average age over the year is associated with about a 2.9 percentage points increase in annual labour productivity growth—which is similar to findings by Wolff (1996). From our results, it follows that the rate of embodied technological change (ψ) during 1970–1997 was 3.5% per year (which is in line with findings by CPB (1992) and Kuipers et al. (1990)).

A decomposition of productivity growth, based on the regression results of Eq. (15), is shown in Table 13. During the 1970s, when the average age of the Dutch capital stock was more or less constant, the vintage effect made a small though positive contribution to labour productivity growth (>4.4%). This changed during the wage moderation period 1984–1997, when the vintage effect became negative: the increase in the average age of capital reduced productivity growth by 0.38 percentage points. It is noteworthy that this drag on productivity growth, created by the ageing of capital, more than offset the positive impact on productivity growth of capital-intensity growth. Table 13 also analyses the contributions of the various factors to the post-1984 slowdown. The slowdown in w/r growth remains the

Table 13
Labour productivity growth, The Netherlands 1970–2000: extended growth accounting II[a,b]

Period	Labour productivity growth $[\dot{Y}/L]$ (1)	Percent point contribution[c]		
		Residual $[\dot{\gamma}^{\text{dis}} + \Pi\psi]$ (2)	w/r growth $[\dot{w}/r]$ (3)	Change in average age of capital stock $\Delta\bar{a}$ (4)
1970–1980	3.61	1.42 (39.4)	2.03 (56.2)	0.16 (4.4)
1984–1997	0.76	1.05 (137.8)	0.09 (11.8)	−0.38 (−49.7)
1995–2000	1.12	0.59 (52.9)	1.21 (108.0)	−0.68 (−60.9)
		Percentage of total change in annual labour productivity growth between 1970–1980 and 1984–1997 explained by:		
	$[\dot{Y}/L]$	Residual	$[\dot{w}/r]$	Capital stock age
	100.0	13.1	68.1	18.8

[a] *Source*: authors' estimates.
[b] Figures in parentheses are percent shares in labour productivity growth.
[c] Calculated using Eq. (15).

most important source of the productivity slowdown (explaining 68%), but it can be seen that the vintage effect is non-negligible: about 19% of the decline in productivity growth is due to the ageing of the capital stock during 1984–1997. Combining these two effects together, real wage moderation—by simultaneously slowing down the process of capital–labour substitution and increasing (via the vintage effect) the average age of capital—can be held responsible for about 86% of the Dutch productivity growth decline.

Finally, note that Table 13 shows that still a very large proportion of labour productivity growth remains unexplained, particularly when the vintage effect is negative. The unexplained residual, which represents disembodied technological change or $\dot{\gamma}_{\mathrm{dis}}$, obviously needs to be explained. We want to remind of one interesting attempt to endogenise the rate of disembodied technological change. In its FKSEC model, CPB (1992) assumes that $\dot{\gamma}_{\mathrm{dis}}$ is endogenous and depends positively on real wage growth and output growth:[6]

$$\dot{\gamma}_{\mathrm{dis}} = \eta_0 + \eta_1 \left[\frac{\dot{w}}{p}\right] + \eta_2 \dot{Y}, \quad \eta_1,\ \eta_2 > 0. \tag{16}$$

Implicit in the hypothesis that $\eta_1 > 0$ is a theory of *induced labour-saving technological change*; according to CPB (1992) estimates, $\eta_1 = 0.41$, which implies that an increase in real wage growth by 1 percentage point will (eventually) raise $\dot{\gamma}_{\mathrm{dis}}$ by 0.4 percentage points. The coefficient η_2 represents the Verdoorn effect; according to CPB (1992), $\eta_2 = 0.3$; a rise in income growth by 1 percentage point hence will increase $\dot{\gamma}_{\mathrm{dis}}$ by 0.3 percentage points.

5.3. *Increasing returns to scale*

Our estimates of TFP growth are derived from Eq. (9), which is based on the assumption of constant returns to scale ($h = 1$). If the production function were subject to increasing rather than constant returns to scale (as argued by new growth theorists), the resulting TFP growth estimates will be lower, i.e. the unexplained residual declines. Hence, we will now return to Eqs. (7) and (8), assuming that $h > 1$. When we compare Eq. (8) to Eq. (9) we can see that—with the assumption of increasing returns to scale—there is an additional determinant of productivity growth, i.c. output growth. It follows that (given that the impact of (w/r) growth on productivity growth is the same in both equations) the residual, taken to be TFP growth, will be smaller in (8) than in (9), when $h > 1$. The output growth effect on productivity growth is the Verdoorn effect. Note that $(h - 1)/h$ is the Verdoorn elasticity, which is economically meaningful only if $h > 1$; the Verdoorn effect is often interpreted as reflecting increasing returns to scale resulting from an expanding market, greater specialisation of production and new investment embodying the latest technology, which in turn allow prices to decline and result in a further expansion of the market (see for instance Wolff (1996)).

We estimated Eq. (7); the results are given in Table 8. The coefficients have the expected signs and are statistically significant; the explanatory power is high ($R^2 = 0.82$). The Verdoorn coefficient (0.70) is higher than Verdoorn's original estimate of 0.5. The implication

[6] Eq. (16) is a simplification, as it neglects the distributed time lag structure included in the FKSEC equation (CPB, 1992, pp. 20–22). This does not, however, affect the essence of the argument. A similar relationship for the explanation of the rate of labour saving technical progress is used by van Schaik and van de Klundert (1978)

Table 14
Labour productivity growth, The Netherlands 1970–2000: extended growth accounting III[a,b] (average annual growth rates)

Period	Labour productivity growth $[\dot{Y}/L]$ (1)	Percent point contribution[c]		
		TFP growth (2)	Growth of w/r $[\dot{w}/r]$ (3)	GDP growth $\dot{Y}$ (4)
1970–1980	3.61	−0.57 (−15.8)	1.87 (51.9)	2.31 (64.0)
1984–1997	0.76	−1.29 (−169.8)	0.09 (11.4)	1.96 (258.4)
1995–2000	1.12	−3.36 (−300.1)	1.10 (97.8)	3.39 (302.3)
		Percentage of total change in annual labour productivity growth between 1970–1980 and 1984–1997 explained by:		
	$[\dot{Y}/L]$	[TFP]	$[\dot{w}/r]$	$[\dot{Y}]$
	100.0	25.2	62.7	12.1

[a] *Source*: authors' estimates.
[b] Figures in parentheses are percent shares in labour productivity growth.
[c] Calculated using Eq. (17).

is that $h = 3.4$, which means that returns to scale are significantly increasing. Substitution of the estimated Eq. (5) into the estimated Eq. (7) gives:

$$\left[\frac{\dot{Y}}{L}\right] = \frac{1}{h}\dot{\gamma} + 0.29\left[\frac{\dot{w}}{r}\right] + 0.70\dot{Y}. \tag{17}$$

Using this expression, labour productivity growth can be decomposed into: (1) a capital–labour substitution effect induced by w/r growth; (2) a Verdoorn effect; and (3) a residual (TFP growth). The results appear in Table 14. Unexplained TFP growth is negative, owing to the fact that the capital deepening effect and the Verdoorn effect—when combined—account for more than 100% of productivity growth; this is in contrast with the constant-returns-to-scale framework, in which productivity growth is seriously underestimated—see Table 9.[7] Further, the contribution to productivity growth of the Verdoorn effect is large and rising over time. At the same time, the contribution of capital deepening (induced by w/r growth) declined: from 52% in the 1970s to 11% during 1984–1997. But the contribution of the decline in w/r growth to the 2.9 percentage points reduction in productivity growth from 1970–1980 to 1984–1997 is large: 63% according to the decomposition scheme of Eq. (17).

Output growth (responsible for the Verdoorn effect), in turn, is related to real wage growth in various ways. First, real wage growth increases consumption demand. Second, (keeping labour productivity constant) real wage increases (relative to abroad) to some extent reduce international cost competitiveness and hence lower export growth. Third, real wage increases may result in a profit squeeze, thereby reducing investment; but they also raise demand, which may stimulate investment through a multiplier-accelerator mechanism.

[7] The 'over-accounting' is due, in part, to the fact that the accounting method is applied on an annual basis to an equation whose parameters have been estimated for a longer period. For another part, it may suggest that the estimated degree of returns to scale h, while likely to be greater than 1, is an overestimation.

The net effect of real wage growth on output growth obviously depends on the parameters of the consumption, investment and export functions (Bhaduri and Marglin, 1990; Bhaskar and Glyn, 1995; Carlin et al., 2001). Instead of a detailed analysis of these parameters, which is beyond the scope of this paper, we estimated the net impact of real wage on output growth as follows:

$$\dot{Y} = \underset{(7.15)}{2.2646^{**}} + \underset{(2.84)}{0.0858^{**}} \left[\frac{\dot{w}}{p}\right], \quad \text{d.f.} = 27,\ \bar{R}^2 = 0.21,\ F = 8.09,\ \text{DW} = 1.66.$$

This equation can be interpreted as the reduced form of a model of the small, open Dutch economy; the estimated coefficient of (w/p) growth thus reflects its *net* impact on output growth via its effects on consumption, exports and investment. The fact that this coefficient is positive, means that the negative effects of higher real wage growth on investment and export growth are more than offset by its positive impact on consumption growth. Hence, a fall in the real wage will lower Dutch GDP growth. If the impact of real wage growth on output growth is taken into account, the total contribution of real wage moderation to the labour productivity decline is 71.1%.

6. Conclusion

Labour productivity growth in The Netherlands shows a sharp break around 1984, 2 years after the start of the policy of wage growth restraint launched in 1982. This paper investigates the contribution of the slowdown in wage growth to the post-1984 decline in labour productivity growth in The Netherlands. That wage growth restraint retards labour productivity growth is suggested by different parts of economic theory—including neo-classical substitution, endogenous growth, vintage models, and models of demand-driven technological progress. Our growth accounting analysis based on the above perspectives suggest the following.

1. Wage moderation has resulted in a decline in the growth rate of relative factor prices (w/r); the decline in w/r growth has slowed down K/L growth which, in turn, influences labour productivity growth.
2. Within a simple CES framework, in which labour productivity growth is explained by the growth rates of K/L and TFP, about 68% of the post-1984 decline in the labour productivity growth rate can be attributed to the decline in the growth of relative factor prices.
3. The simple CES framework is unsatisfactory because it leaves TFP growth unexplained. Within an extended CES framework, in which various additional channels of transmission of input price pressure are taken into account, the impact of wage moderation was found to be even larger while the importance of unexplained TFP growth is reduced. Specifically, it can be listed as follows.
   (a) Capital accumulation per hour worked (K/L) and technological advance (TFP) interact. Because K/L growth is, in turn, influenced by the growth rate of relative factor prices, the implication is that TFP growth is related to relative factor price changes.

If its effects on TFP growth are taken into account, wage moderation explains more than 100% of the labour productivity growth slowdown.

(b) The relationship between w/r growth and TFP growth remains unsatisfactory, however, if we do not specify explicitly what it means. Two likely channels through which w/r growth influences TFP growth are capital stock age and demand. Regarding the first, we find that the average age of the Dutch capital stock has increased during 1984–1997 and that this change in the average age is negatively related to real wage growth. If its effect on the capital stock age is taken into account, wage moderation contributes 86% to the post-1984 decline in labour productivity growth.

(c) Within an increasing-returns-to-scale production function framework, the contribution to labour productivity growth of w/r growth depends not only on its impact on K/L substitution but also on its impact on the growth of aggregate demand. The total contribution of the decline in w/r growth on the labour productivity growth slowdown—via the two channels—is estimated to be 71%.

Together, these findings point to very substantial contributions (of two-thirds or more) of wage moderation to the post-1984 productivity growth slowdown in The Netherlands—both directly (via capital–labour substitution) and indirectly (via TFP growth, vintage and Verdoorn effects).

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Appendix A. Data

Employment: Estimates of employment (in hours worked) for most years during 1950–2000 are available from the Groningen Growth and Development Centre (2002); estimates of hours worked for years for which employment data are missing, were obtained by means of interpolation.

Capital stock: Estimates of the Dutch capital stock during 1950–1992 are available from Maddison (1996). We constructed capital stock estimates for the period 1993–2000 using a perpetual-inventory method and assuming a fixed service life for assets (see Wolff (1996, p. 1240)).

Capital intensity: Using these estimates of employment and capital stock, we constructed a time-series (1969–2000) of capital intensity K/L.

Growth rate of the labour–capital price ratio: The national accounts provide time-series data (1969–2000) on nominal wage income wL and capital income rK. Using these data and the time-series data on L and K, we constructed time-series of w and r as well as of the growth rate of relative factor prices for our reference period 1969–2000 (see Table 4, Section 3).

Distribution parameter: When the elasticity of substitution is known, the parameter d can be derived from national accounts data on factor shares. To do so, we multiply both sides of Eq. (4) by r/w to obtain:

$$\frac{rK}{wL} = \left[\frac{\delta}{1-\delta}\right]^{-\sigma} \left[\frac{w}{r}\right]^{\sigma-1}.$$

Given σ, and using national accounts data on relative factor incomes rK/wL and relative factor prices w/r, we derived annual estimates for δ for the period 1969–2000.

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