Three Phases of Dutch Economic Growth and Technological Change , 1815-1997

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Abstract
In this paper we analyze the dynamics of Dutch economic growth for the period 1815-1997. By applying a simple econometric technique, important braking points in the timeseries are traced. It seems that three phases of growth can be discerned and that these phases are characterized by different types of technology (steam, electricity as well as information and communication technology). The Dutch economy has not generated an overall productivity improvement from the first and third technological phase, but has been successful in exploiting the technological opportunities of the second phase.

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I. Introduction

One of the main interests of economic historians is to distinguish different phases of economic growth. There is, for example, a huge amount of literature on 'long waves' of growth. Recently Gordon presented a provocative paper on the growth pattern of the American economy, in which he suggested that the period 1913-1972 in fact was 'one big wave' (Gordon, 1999). In his article he stated that not the post-1972 productivity slowdown is the phenomenon that needs to be explained, but that the high growth rates in the preceding era deserve more attention. According to Gordon the productivity slowdown can to some extent be seen as the return to a 'normal' growth path.

Unfortunately it is only possible for a limited number of countries to test this hypothesis. Most countries simply lack the data to analyse the dynamics of long term economic growth. The Netherlands is one of the few countries for which sufficient data are available to study the process of long term economic development. Statistics Netherlands was one of the first statistical offices in the world that published historical statistics from the 1920s onwards. These estimates have been recently updated (Den Bakker et al., 1987). In 1990 a large-scale research project was financed with the aim to construct a consistent dataset of national accounts for the period 1800-1921. (Smits et al., forthcoming.) Hence, we now have data for almost two centuries, which allows us to study the issue of periodisation of the growth process in the Netherlands in detail.

In this paper we focus on four key macroeconomic variables: output, labour productivity, total factor productivity and capital intensity. Section II of this paper gives a brief overview of the current thinking in the economic-historical literature on the timing of Dutch economic growth. It raises much-debated but still largely unresolved questions which relate to the slow productivity growth during the (late) nineteenth century, the rapid increases in productivity levels in the 1950s and 1960s and to the post-1973 productivity slowdown.

The periodisation of the growth process in the literature is mostly based on ad-hoc and descriptive arguments. In section III, therefore, a simple econometric analysis is presented which may shed some new light on periodization. Section IV is devoted to the interpretation of these results and tries to explain the acceleration and deceleration of growth rates between these phases by changes in technological-economic systems.

It should be stressed from the outset that despite the great care with which the database for two centuries is constructed, there are some breaks in the methodology by which the series are estimated, in particular around 1921 and around 1969. The reliability and coverage of the basic material declines the more we go back into the nineteenth century, and in particular the more disaggregated the data are (for example output estimates at branch level). However, at the aggregate level we believe our series are robust and can be used for the kind of analysis undertaken here. Given recent developments in the growth literature we would have liked to pay more attention to the role of such factors as human capital and knowledge spillovers. These are are largely ignored simply because we do not have these data for the early years of our long period.[2] In future research we hope to incorporate these elements as well as more advanced types of growth accounting in our analysis.

II. Current Historical Interpretations of Dutch Economic Growth 1815-1997

During the seventeenth century the Netherlands was the productivity and technology leader of the western world, but it gradually lost ground to the British economy during the eighteenth and nineteenth century. The reasons for this are multifold, ranging from the mercantilist policies of the larger neighbour states, the entrenched interests of commerce, the burden of fiscal policies and an overvalued currency. Still, levels of GDP per manhour in the Netherlands remained among the highest in the world. In 1870 only Australian, British and American productivity levels were higher than those of the Netherlands (Maddison, 1991, 1995).

Until recently there was no clear picture of the dynamics of Dutch economic development during the nineteenth century. Most qualitative studies suggested that the economy was stagnant and lacked the necessary conditions to benefit from the first industrial revolution (De Vries, 1968). Quantitative studies, which were mostly restricted to some industries or to rather short periods, displayed divergent results. Griffiths and De Meere maintained that the 1830s and 1840s were a period of economic expansion (Griffiths, 1979 and De Meere, 1983), while Brugmans considered the 1860s as a turning point in the growth process (Brugmans, 1983). De Jonge, however, stated that the period after 1895 has been crucial for economic development (De Jonge, 1976). The analysis of De Jonge has been influential, tied as it was to the popular Rostowian notion of 'take off', implicitly indicating that the modernisation of the Dutch economy still had been slow and lagging behind the European average.

The recent evidence which has emerged from the project on 'Reconstruction of the National Accounts of the Netherlands' indicates that - from a macro-economic perspective - the nineteenth century growth process was rather balanced. No dramatic acceleration of growth rates can be discerned throughout the period 1800-1913. Table 1 shows nineteenth century annual growth rates of GDP varying between 1.5 and 2 per cent per year. In fact, the first half of the nineteenth century shows higher growth rates of GDP per capita than the second half. In comparison with Northwest-Europe GDP per capita growth is lower after 1850. Part of this modest growth can be explained by

[2] Albers (1998) stresses that human capital and knowledge spillovers are less important for growth in the nineteenth than in the twentieth century. Even growth accounting estimates for the twentieth century suggests a limited contribution of human capital and R&D to the growth process, see Van Ark and De Jong, 1996.

high population growth which was a main characteristic of the Dutch economy until recently.

Table 1. Gross Domestic Product, GDP per Capita and GDP per Hour Worked, 1820-1913 (annual compound growth rates)

Netherlands

	GDP	GDP/Cap	GDP/Hour
1820-1850	2.1	1.1	
1850-1870	1.6	0.9	
1870-1890	2.0	0.8	1.3
1890-1913	2.4	1.0	1.3

NW Europe (unweighted average)

	GDP	GDP/Cap	GDP/Hour
1820-1850	1.6	0.8	
1850-1870	1.6	1.0	
1870-1890	1.8	1.0	1.5
1890-1913	2.2	1.3	1.6

Source: Dutch data derived from: Smits et al., forthcoming. For other data, see: Maddison (1995).

Another main conclusion which can be drawn from the recent evidence, is that the Dutch nineteenth century growth process was not accompanied by large structural changes in the employment structure as was the case in many other European countries (Crafts, 1985). The structure of the Dutch economy showed a more or less evenly distribution of employment. Agriculture, industry and services accounted for roughly 40, 30 and 30 per cent of total employment respectively. Contrary to other countries differences in levels of productivity between the sectors were quite small. Dutch labour productivity levels in the service sectors were high and differences in productivity levels between industry and agriculture were small until about 1870.

This had two implications. First of all, incentives leading to shifts of economic activities between sectors were small. Secondly, when the shifts eventually took place, these had only limited effects on the macro-economic growth performance. The forces of "modern economic growth" (Kuznets, 1966) were clearly not at work, as far as employment shifts from agriculture towards manufacturing and services were concerned. Only after the 1870s, when agrarian prices dropped sharply due to the Great Depression, nominal levels of labour productivity in agriculture fell and the share of agrarian employment decreased.

The absence of structural change during most of the nineteenth century begs the question what happened to productivity growth. As the Dutch historical national accounts project also delivered estimates of physical capital, TFP measures could be computed (Groote, 1995; Albers, 1998). During the period 1807-1854 the TFP growth rate was 0.57 per cent, which accounts for about 40 per cent of total GDP growth. This relatively high contribution from TFP growth may be due to below-potential output growth and underutilisation of the capital stock during the Napoleonic period. TFP growth after 1854 was much lower. During the period between 1854 and 1896, labelled by Albers as the ‘transition to the first stages of modern economic growth’, TFP growth is only 0.24 per cent. During this period the growth of fixed capital became the main driving force of labour productivity growth, with technical progress being captured in fixed tangible capital. The period from 1896 to 1913 again shows low TFP growth (0.22 per cent), but GDP and labour productivity growth were higher. During this period the composition of capital changed towards machinery capital (Albers, 1998).

Compared to the nineteenth century, the twentieth century is characterised by major changes in structure and substantial variations in growth rates of the Dutch economy. Table 2 shows growth rates of GDP, per capita income and labour productivity as updated from an earlier study by Van Ark and De Jong (1996)

Table 2. Gross Domestic Product, GDP per Capita, GDP per Hour Worked and TFP, 1913-1998 (annual compound growth rates)

Netherlands

	GDP	GDP/Cap.	GDP/Hour	TFP
1913-1929	3.66	2.16	3.23	2.35
1929-1947	0.52	-0.66	0.36	-0.46
1947-1973	5.09	3.75	4.28	2.79
1973-1998	2.39	1.76	2.36	1.52
1913-1998	3.05	1.92	2.54	1.67

NW Europe (unweighted average)

	GDP	GDP/Cap.	GDP/Hour
1913-1929	2.16	1.42	2.14
1929-1947	1.73	0.49	1.54
1947-1973	4.86	3.74	4.41
1973-1998	2.04	1.68	2.34
1913-1998	2.85	2.00	2.66

Note: Intervals for GDP/Hour rates refer to the year 1950 instead of 1947
Source: Van Ark & De Jong (1996)

The intervals which were used by Van Ark and De Jong were more or less determined by the periodisation of the major events of the century. The long term GDP growth rate is calculated at just over 3.0 per cent annually, which is similar to rates in other Northwest-European countries and the United States. Exceptionally high growth for the Netherlands was found for the period 1913-1929. In the literature it is argued that the strong performane can be explained by the fact that the Netherlands were not involved directly in the hostilities of World War I, and were able to benefit from the increased foreign demand after the war. (Van der Bie, 1995) For the 1930s and 1940s growth rates are very low, as the Dutch economy stuck to the Gold Standard until 1936, thereby seriously affecting the competitiveness of the Dutch economy. (Van Zanden, 1988)

Just like most other Northwest-European countries, the Dutch economy had fallen far behind the world technology and productivity frontiers during the Second World War, which created a huge potential for catch-up during the period 1947-1973. The Dutch growth process during the 1950s was strongly driven by low wages, but substantial intensifying of capital use took place during the 1960s. Like other countries, the Dutch economy experienced a slowdown since 1973 due to the breakdown of the Bretton Woods system and the first oil crisis. Moreover, the growth slowdown since the early 1970s was at least partly related to an exhaustion of the possibility for catch-up with the United

States (Crafts and Toniolo, 1996). However, the second oil crisis in 1979 hit the Dutch economy much harder than the first, as the effects of over-expansionary policies during the 1970's in combination with a loss of competitiveness partly due to huge gas exports (the "Dutch disease") led to a serious crisis around the early 1980s. The latter sparked off a new prolongued phase of wage moderation, huge restructuring of the manufacturing sector, and a substantial expansion of service sector activity.[3]

It is striking that growth since 1973 has been much slower not only compared to the "golden age" from 1947-73, but also compared to the earlier part of the century. Hence the slowdown of growth rates since 1973 cannot be seen as just a 'return to normalcy' as was observed for many other European countries (Van Ark and De Jong, 1996). Recently Van Zanden confirmed this viewpoint in stressing the relatively good performance of the economy (not only the Dutch) during the 1920s. He labeled this period as a first growth spurt, characterised by a decisive acceleration and representing the precursor of the postwar golden age. A further implication would be that the post-1973 period is the beginning of a different growth regime, succeeding the regime established in the first part of the century, which in its turn was preceeded by another during the nineteenth century regime between 1820 and 1920 (Van Zanden and van Riel, 1998). This interpretation comes close to that of Gordon (1998) on the U.S. economy, who claims that period that the period 1913-1972 can be seen as 'one big wave'. However, Gordon's analysis is based on a much more sophisticated growth accounting analysis, measuring not only changes in quantities but also qualities of factor inputs. This is an issue for further research on Dutch economic growth.

III. Testing for phases of long run growth

For both the nineteenth and twentienth centuries the choice of the time intervals on the basis of the current historical interpretations is somewhat ad-hoc, and mainly derived from casual observation of the estimates in combination with exogeneous shocks (like wars) and changes in institutions (like the wage bargaining system in the Netherlands). When observing sub-periods of accelerated and decelerated growth, it is difficult to control for the impact of these events and to isolate the more 'structural' forces at work. More specifically, we are interested in structural breaks due to changes in technological-economic regimes.

For this purpose, we tested our series for structural breaks using Chow-tests for parameter stability in our series on GDP, labour productivity, capital intensity and total factor productivity for the period 1815 - 1997. The Chow test is a standard F test for the equality of two sets of coefficients in linear regression models. (Chow, 1960) In our basic model we regress the observed growth rates on a

[3] See also Van Ark, De Haan and de Jong (1996) as well as Van Ark and De Haan (1997)

constant. The estimated coefficient equals the average growth rate of the entire period. Next, we check whether the estimated coefficient was stable over time. To do so, we include a dummy which equals zero prior to the potential break and equals one otherwise. In case the dummy is significantly different from zero, the average growth rate prior to the potential break can be interpreted as statistically not equal to the average growth rate after the potential break. This procedure is repeated for each year. The year for which the additional dummy is most significant is taken as the year in which the first structural break appears. The basic model then includes two dummies. The first equals one prior to the break and zero otherwise, the second the other way around. Hence, the new regression results give us two average growth rates; one for the period prior to the break and one for the period after the break. Using this new model we can repeat the above procedure and check whether there is another significant structural break until we no longer find a significant additional dummy for each year. The final regression model shows different average growth rates for different periods distinguished by the statistical procedure.

Obviously this statistical procedure only tests the growth rates as such without taking into account the different causes of the breaks. However, in combination with an economic-historical analysis, this approach may help us to determine the long run impact of particular break.[4] At the 10 per cent level the Chow tests reveal the following results (see also the appendix):

1. The tests reveal a clear structural break in the series around 1916. In the GDP series we find a regression coefficient of 1.8 for the period 1816-1916, which means that the estimated coefficient is stable over a period of 100 years. After the First World War GDP growth is raised to a much higher level (4%-4.5%), but the depression of the 1930s and the Second World War show negative rates. The year 1916 also appears to be a breaking point in the long term development of GDP per hour, showing a stable growth rate of 1.0 per cent from 1817 to 1916 and higher levels thereafter. As far as TFP growth is concerned, the differences for the years before and after 1916 are really striking. Before 1916 the coefficient is 0.7 and after the break 1.4, indicating two clearly different regimes of efficiency for the nineteenth and twentieth centuries.
2. The second important finding is that in the series on GDP and labour productivity a structural break can be discerned around 1975. The growth rate of GDP since 1975 is very close to the nineteenth century figure, but the labour productivity growth rate declined to a level which is still 0.7 per cent point above the nineteenth century level of 1.0 per cent. At the same time the TFP growth rate is stable, which is primarily caused by the decline in capital intensity after 1970.

[4] It should also be emphasised that we only test for breaks in the growth rates, and not for possible trend stationarity which would require the estimation of levels and tests for unit roots.

3. The tests suggest fairly continuous upward trends in capital intensity, in particular around 1950. Another break towards a downward trend occurs around 1973. These breaking points are largely explained from substantial changes in the structure of the economy, i.e. the relative strong growth of capital intensive petro-chemical industries during the 1950s and 1960s, and the rapid increase of service industries from the early 1970s onwards.

IV. Phases of Technological Change

In the 1950s, both empirical and theoretical work concluded that labour productivity changes should be seen as the driving force in the growth process (Solow, 1957 and Kuznets, 1966). Indeed, our data show that economic growth in the long run is largely the result of increases in output per unit of labour. But how can these enormous efficiency gains be explained? Solow’s growth model states that economic growth is primarily driven by a rise in the capital-output ratio. However, as the returns on capital accumulation diminish, the economy will converge to the so-called steady state.

Empirical research, however, unequivocally shows that in the long run no systematic decrease of diminishing returns on capital nor a slowdown in the growth of labour productivity can be discerned, notwithstanding the productivity slowdown since 1973. This has led neoclassical economists to introduce technological change (in the guise of TFP) in the production function in order to 'allow' economies to continue growing in the long run. In other words, (exogeneous) technological change may compensate for the tendency of diminishing returns on capital investments.

We find these arguments also in the economic-historical literature. In his analysis of technological developments in the long run, Joel Mokyr makes a distinction between macro and micro inventions. (Mokyr, 1990) Macro inventions are more or less exogenous technological shocks, which create new production possibilities (steam engine, electrical motor, computer chip). After the introduction of a macro invention, the new technological concept will be adapted to entrepreneurial needs by means of processes of learning-by-doing, learning-by-using and/or learning-by-interacting. This process of technological adaption and diffusion is, however, characterized by diminishing returns. Mokyr argues that productivity growth in the long run will only be secured if from time to time macro inventions are introduced which create new growth possibilities.

Macro inventions have the tendency to manifest themselves in clusters. As stated by Freeman and Soete (1997, p. 31) there seem to be “... systematic interdependencies of myriad technical and organizational innovations. Like Hamlets' troubles, they come not single but in battalions. Process innovations, product innovations, organizational innovations and material innovations are all interdependent in mechanization, electrification or computerization.” If we accept the notion that radical new technologies arise in clusters and that they can create new growth possibilities, it is possible that long term fluctuations in economic growth are somehow linked to changes in technological systems.

On the basis of our tests and the evidence from the literature, we distinguish three phases of technological change for the period 1800-1997:[5]

1) First industrial revolution: +/- 1800-1913, technology based on steam

2) Second industrial revolution: +/- 1890-1990, technology based on electricity

3) The 'third wave' or the IT-revolution: +/- 1973-…. based on information and communication technologies

We deliberately let these phases overlap as there is plenty of evidence that key technologies can co-exist for quite some time. We also realise that the key technologies are not all inclusive. For example, for the most recent period the rise of bio-technology is another key technology next to information and communication technology with great potential for long run growth. In the remainder of this paper we will analye Dutch economic growth in the light of the changes in these technological-economic systems.

[5] This periodization closely resembles that of Freeman and Soete (1987): first industrial revolution (ca. 1780-ca. 1890), second industrial revolution (ca. 1890-ca. 1990) and the 'third wave' (ca. 1990-??).

The first phase (c. 1800-c. 1913)

During the nineteenth century, productivity growth in the Dutch economy was clearly below Northwestern European average.[6] Although the Dutch Republic in the seventeenth century was at the technological frontier, this leading role was in the course of the eighteenth century overtaken by the British.[7] In the late eighteenth and early nineteenth century the Dutch had great difficulties in adapting their economic and institutional structures to the new technologies which were developed by the British. The diffusion of new technologies (especially steam technology) went rather slow. In the period 1840-1865 labour productivity in manufacturing even declined. Also innovation and investment indicators point at a structural hold-up during these years.

This technological inertia is quite remarkable in the light of the almost continuous decline of profit margins with which industrial firms were confronted, and which can be explained from the scale problems which Dutch firm owners were facing. In the seventeenth and eighteenth centuries industrial products from the Netherlands were to a large extent sold on the world market. In this pre-modern, trade-capitalist system exports and industrial development were narrowly intertwined, and the domestic market was not strongly developed.

The decline of the Dutch share in world trade that started during the eighteenth century, and accelerated during the Napoleonic Wars when the Dutch lost their export markets, including large parts of their own colonial market. As the domestic market in this period was small and weakly integrated, entrepreneurs suffered from external diseconomies of scale. Indeed, an analysis of the cost of production shows that it was not profitable to introduce steam technologies in most branches of industry until the 1860s (Lintsen et al., 1992).

Since the 1860s the scale constraints were gradually removed, and an important change in entrepreneurial behaviour occurred. Dutch firm owners started to invest in cost reducing (often labour saving) technologies in order to increase their competitive strength. From the 1860s onwards a strong increase in real wages can be discerned, which resulted in a significant increase in domestic demand for industrial (consumer) products. Furthermore, the abolition of indirect taxes on a number of primary products (bread, meat) had a positive impact on purchasing power. This 'demand shock' made it possible for entrepreneurs to produce on a larger scale than before and to invest in new (steam) technologies. In the course of the 1860s and 1870s the costs of mechanised production became significantly lower than the costs of handicraft production. Between 1850 and 1890 the share of steam engines rose from 5% to over 60% of total machinery.

[6] In the period 1850-1870 average annual growth rates of labour productivity amounted to 0.7 per cent in the Netherlands compared to about 1.1 per cent in the other Northwest European countries. In the period 1870-1913 these growth rates amounted to 1.2% and 1.7% respectively.

[7] The following text on nineteenth century economic growth is largely based on Smits (1999).

Nevertheless, the acceleration of technological change did not result in higher growth rates in comparison to other countries. On the contrary, Dutch growth rates of output and productivity were comparatively low. How should the relatively poor productivity performance in the (late) nineteenth century be interpreted? One possible reason is that even in 1890 the share of steam engines was still very unevenly distributed across the manufacturing sector (see table 3).

Table 3: Productivity performance of several branches of industry (1865-1913, average annual growth rates) compared with use of steam power (number as steam engines as a % of total machinery in 1890)

Branch	Productivity growth	Share of steam engines
Total manufacturing	+1.8	61
Of which:		
-Textiles	+1.8	97
-Metals and shipbuilding	+3.1	95
-Paper	+4.4	100
-Chemicals	+1.1	45
-Food	+1.1	43

Source: Smits et al., forthcoming and Lintsen et al (1992).

The diffusion was rather successful in shipbuilding and mining (where already in 1850 the share of steam engines in total powered equipment was 100 per cent) and paper (in this branch all other types of powered equipment were removed by steam engines in 1860). However, especially in the food processing industries, handicraft techniques and machinery driven by, for example, water- and windmills continued to dominate until at least 1890.

In some of these industries the introduction of steam technology was not possible for technical reasons (Lintsen et al., 1992). Table 3 reveals that productivity growth rates were relatively low in branches where steam engines were not frequently used and vice versa. Efficiency increases in the food processing and chemical industries became only possible after the introduction of electrical motors.

The inability to innovate in key sectors within Dutch manufacturing eventually resulted in negative growth rates of total factor productivity. Just as TFP *growth* can be interpreted in terms of real cost declines, TFP *reductions* can be seen as rises in real costs as non-innovating inputs become increasingly expensive (Harberger, 1998).[8] During the period 1870-1913 Dutch industrial export prices witnessed a clear downward trend relative to the costs of inputs (especially labour costs). Eventually the competitive strength of the Dutch economy was weakened by this inability to innovate. Not only was the productivity performance well below Northwest European average, also the share of Dutch exports in world trade almost continuously decreased in the period 1870-1913.

[8] While the TFP growth rates for the economy as a whole decrease in the late nineteenth century, TFP in manufacturing even shows a decline in absolute terms.

The second phase (c. 1890-c. 1990)

From the 1890s onwards the Netherlands began to reap the benefits of the economic restructuring which had occurred in the preceding decades. Technological diffusion now became relatively easy, because the impediments for further scale improvements had been removed during the nineteenth century. During the twentieth century the Netherlands were among the most successful followers of the second industrial revolution.

The technological transition from 'steam' to 'electricity' gained extra momentum during the first World War, which in fact is the first real breaking point in our time series. In this period high wages were an incentive to invest in cost-reducing technologies. Furthermore, the Dutch - who were neutral during this war - strongly benefitted from the huge demand for (consumer) goods from countries which that were engaged in war and not able to meet their own demand any longer. This strong increase in demand acted as an extra impulse to invest in new production methods.

At the time that the new technologies became available, productivity gains could eventually be realised in industries like the food processing and chemical industries, sectors in which the application of steam had proven to be difficult for technical reasons. The new technological opportunities of these industries as well as the huge post-war demand for Dutch products on the international market boosted productivity growth.

At first sight the 1930s appears an outlier within the the second phase from 1913 to 1975. Output growth in this period was low compared to the growth rates that were realised during the 1920s, 1950s and 1960s. However, this poor performance is partly explained by the depression of the 1930s in combination with the misguided monetary policy that the Dutch government pursued in this period (Van Ark, De Haan and De Jong, 1996). The Netherlands stuck to the Gold Standard until 1936 (while most other countries devaluated their currencies in the early 1930s), which seriously undermined the competitive strength of the economy.

In this light it is all the more remarkable that labour productivity in manufacturing witnessed quite impressive growth rates even during the 1930s (De Jong, 1999). Midway the 1930s labour productivity in Dutch manufacturing was 6 to 7% above the British, Belgian and German levels. This process of rationalisation and efficiency increases can be seen as an attempt to compensate for the relatively high (nominal) wages, which put profit margins of industrial firms under pressure. The rapid diffusion of cost reducing technologies (especially electrical motors) proved a successful way to save on labour costs and to increase the levels of productivity. From a technological perspective, the 1930s can therefore still be seen as an integral part of the second technology phase .

Contrary to the First World War, the Second World War did not change the technological paradigm of the Dutch economy. Of course due to the war the Dutch economy, like the other European countries, had fallen far behind the world technology and productivity frontier, which created a huge potential for catch-up with the United States. Yet this had no far-reaching impact on the technologies that were used in most industries. This does not mean, however, that there were no significant technological changes within the paradigm of the second technology phase . Freeman and Soete (1997) argue that in the 1940s the second industrial revolution was substantially broadened. Especially in the 1950s and 1960s energy-intensive production processes became increasingly important (see table 4). The petro-chemical sector became one of the leading sectors in Dutch manufacturing.

Tabel 4: International comparison of the energy-intensity in some western countries, 1913-1987 (in Pjoules per unit of GDP)

	1913	1950	1973	1987
Netherlands	398.2	298.3	458.1	408.6
France	498.7	372.2	334.0	279.5
(West) Germany	904.9	562.7	424.8	339.7
Japan	377.0	343.5	337.6	225.7
Great-Britain	889.9	556.2	390.3	292.1
United States	922.2	660.5	588.7	439.2

Source: Maddison, 1991.

Already by the beginning of the 1970s the Netherlands had become one of the most energy-intensive economies in the world. In this respect the Dutch economy benefited from a combination of factors, including the discovery of natural gas which lowered energy prices, locational advantages of Dutch ports for storing oil reserves, and the sharp rise in wages from the early 1960s onwards which facilitated the strong growth of a number of capital intensive branches.

A third phase ? (c. 1973-present)

Since the early 1970s, GDP growth in the Netherlands has slowed down, as in most other advanced economies. However, compared to the rest of Northwest Europe the Dutch performance in terms of per capita income did not deteriorate much during the 1970s, and the comparative level of labour productivity and total factor productivity even improved slightly relative to the neighbour countries (Van Ark, De Haan and De Jong, 1996). Hence there is no reason to reject the notion that the 1970s were still part of the second technology phase. In fact, the first oil shock of 1973 did not hit the Dutch economy so hard, and due to the natural gas resources in combination with the gradual rise in the export price of gas, the terms of trade of the Netherlands were not as seriously affected as in countries which were more dependent on oil imports. Moreover, private and public consumption continued to grow during the 1970s so that demand restrictions were limited.

Towards the end of the 1970s many indicators pointed in the direction of a shrinking economy, i.e. one which created less output growth with even less input growth. A report by the Scientific Council for Government Policy written in 1980 concluded that the Dutch industrial sector had become weak in traditionally strong and competitive areas – like the petro-chemical complex -, and had not made much progress in new, technologically advanced areas (WRR, 1980). Between the mid 1970s and mid 1980s manufacturing output growth was more or less stagnant and manufacturing labour input declined by about 25 per cent.

One important trend that deserves further attention, and which was also clearly picked up in the Chow tests carried out in section 3, is the strong slowdown in growth of capital intensity from well above 5 per cent per year during the 1950s and 1960s to only about 2 per cent since 1973. This decline in the growth rate partly reflects a phenomenon which has also taken place elsewhere in Europe, due to the exhaustion of the catch-up potential in Europe vis-à-vis the United States (see table 5). For the other part , the slowdown in capital intensity seems to be not even a pure European phenomenon either, as the growth rate of capital intensity growth in the United States declined to just over 1 per cent since the mid 1980s. Since the late 1980s capital intensity ratios between Europe and the United States were more similar than before.

Table 5. Nonresidential Capital Stock per Hour Worked, % of the US and annual average growth rates

	France	Germany (West)	Nether-Lands	United States
1950	35.9	28.4	34.5	100
1960	40.8	33.3	45.7	100
1973	66.0	69.1	72.7	100
1985	105.0	92.6	93.7	100
1996	127.2	111.4	104.7	100
1950-60	4.1	4.4	5.6	2.7
1960-73	5.7	7.7	5.5	1.8
1973-85	6.1	4.6	4.2	2.1
1985-96	2.8	2.7	2.1	1.0

Netherlands: 1990-96 on the basis of perpetual inven-
Tory method using standard assumptions on asset
Lives and scrapping as in Maddison (1995); 1950-90
Trend from Groote, Albers, and De Jong (1996)

Other countries from Maddison (1995), updated to 1996
With investment series from OECD and adjusted to
1993 US price levels

The general slowdown in capital intensity in many advanced countries raises the broader issue of the overall productivity paradox, namely that the typical technologies of the third technology wave, which are information and communication technologies (ICT), are not reflected in increased productivity growth. It goes beyond the scope of this paper to deal with this issue in detail.[9] One possible hypothesis is that the new technologies only have an impact on productivity with a substantial time lag as has also been observed for other major new technological paradigms (such as the introduction of electricity during the upward phase of the second wave has proven) in the past (David, 1990). Another hypothesis is that the third technology wave is not as capital intensive as the second, as IT equipment accounts for a much smaller share of the total capital stock now than electrical machinery at the beginning of this century.

For most countries estimates of computer capital as a share of the overall capital stock are still lacking. Recent American and British data suggest that on average computing equipment does not account for much more than 2 per cent of the total capital stock. However, as the growth of ICT capital is much faster than that of other capital, investment shares of ICT hardware are somewhat higher at, for example, 4 per cent on average for the Netherlands between 1983 and 1997 (Minne, 1995, updated with CBS series). However, rapid investment growth does not necessarily mean a big impact on productivity, because computers, which show huge price declines, are usually substituted for other capital, i.e. one input for another (Jorgenson and Stiroh, 1999).

The low productivity impact from ICT capital may be reinforced by the fact that with the rise of service sectors in the economy, there is even less scope for productivity-enhancing investment in ICT technology. In this respect the Dutch case may be of particular interest, as the above average decline in capital intensity in the Netherlands may be explained from the huge structural transformation of the Dutch economy since the mid 1980s from capital intensive manufacturing towards services. Almost two-thirds of real output growth in the Netherlands between 1987 and 1997 was accounted for by market services, compared to just over 50 per cent in France and 60 per cent in the UK. In Germany the expansion of real output in market services was even faster than in the Netherlands, but the German employment share in market services was 43 per cent against 61 per cent in the Netherlands. In the United States market services contributed 70 per cent to real output growth between 1987 and 1997, and its employment share was exactly the same as in the Netherlands.[10]

Much of the slow labour productivity growth since the mid 1980s, which was only 1.7 per cent per year between 1987 and 1997 (compared to 2.1 per cent for the whole European Union) can be ascribed to slow productivity growth in services (which was virtually zero in financial and business

[9] For a good review of the main issues, see Triplett (1999)

[10] These estimates are derived from the GGDC (Groningen Growth and Development Centre) Sectoral Data Base, which is based on national accounts sources and employment statistics (van Ark, 1996)

services, about 0.4 per cent in distribution, and as a major exception 3-4 per cent in transport and communication). And within services this slow productivity is partly due to lower capital intensity growth but also to lower total factor productivity growth. No doubt part of the slow output growth in services is due to measurement problems (Griliches, 1994). However, as it appears that capital intensity in service sectors also increased a good deal slower than in manufacturing, we need to look for more substantial explanations as well. Estimates for finance, insurance and business services, which are particular heavy users of ICT capital, show virtually zero productivity growth for the Netherlands, both in terms of labour productivity and total factor productivity.[11]

When evaluating the impact of the third technology wave on growth there may be an important analogy with the first technology phase (and not the second). ICT capital (like steam) may be useful for some industries and sectors, but is not as encompassing in its productivity effect as electricity. In services which account for a large share of the Dutch economy, computer technology appears not effective as a driver of output growth. Despite large increases in computer capital, overal capital intensity in these sectors has declined but with no effect on labour productivity. Of course, new applications of ICT or the emergence of complementary inputs may eventually lead to a productivity effect of ICT in inputs. Alternatively, a bigger impact may be expected from manufacturing. Indeed CPB (1998) recently recorded an acceleration in manufacturing productivity growth since 1991, in particular in the chemical complex and in food processing. But given its relatively small size, the productivity effects from the manufacturing sector will make less impact on overall productivity growth than a better performance of services.

IV. Conclusion

In this paper we analysed almost two centuries of data on economic growth in the Netherlands. By applying a simple econometric technique we were able to trace important breaking points in the process of long term economic growth. By analysing the data we distinguished three partly overlapping technology phases which ran from 1800 to 1913 (steam), from 1890 to 1990 (electricity) and from 1973 to present (information and communication technology). Our main observations are that the Dutch economy has not generated an overall productivity improvement from the first technology phase but that it has been extremely successful in exploiting the technological opportunities of the second phase. There are strong indications that the shift from the first to the second phase has been of greater importance than the technological transformation which occurs nowadays. The same conclusion can be drawn from the work of Goldin and Katz who state that

[11] See Van Ark and de Haan (1997) and CPB (1998). CPB even observed negative labour productivity and TFP growth rates for these services since 1991 but a recovery of manufacturing productivity growth since the early 1990s.

during the second phase capital and high skilled labour were no longer substitutes, but were highly complementary. (Goldin and Katz, 1996). This might explain the huge economic effects of the introduction of the new technologies of the second phase in terms of productivity growth.

Although not working with exactly the same kind of data as Gordon used for the USA, this research clearly shows that the period from 1913 until the early 1970s indeed can be seen as a ‘one big wave’ in which growth rates of output and productivity were significantly higher than in preceding and following periods. The productivity gains from the ICT revolution are still an open question, but we observe particularly low impact on the Dutch economy, because of its relatively large output and employment share in services.

References

-Albers, R.M. (1998) *Machinery investment and economic growth: the dynamics of Dutch development 1800-1913*. Unpublished Ph.D Dissertation, Groningen.

-Ark, B. van (1996), Sectoral Growth Accounting and Structural Change in Post-War Europe, in B. van Ark and N.F.R. Crafts, eds., *Quantitative Aspects of Post-War European Economic Growth*, CEPR/Cambridge University Press, pp. 84-164.

-Ark, B. van & H.J. de Jong (1996). Accounting for Economic Growth in the Netherlands Since 1913. *Economic and Social History in the Netherlands 7*, pp. 199-242.

-Ark, Bart van, Jakob de Haan and Herman de Jong (1996), Characteristics of Economic Growth in the Netherlands During the Postwar Period, in Nicholas Crafts and Gianni Toniolo, eds., *Economic Growth in Europe Since 1945*, CEPR/Cambridge University Press.

-Ark, Bart van, and Jakob de Haan (1997), The Delta-Model Revisited: Recent Trends in the Structural Performance of the Dutch Economy, *Research Memorandum GD-38*, Groningen Growth and Development Centre.

-Bakker, G.P. den, C.A. van Bochove and Th.A. Huitker (1987), *Macro-economische ontwikkelingen, 1921-1939 en 1969-1985*, 's-Gravenhage, Staatsuitgeverij.

-Bie, R.J. van der, *Eene doorlopende groote roes. De economische ontwikkeling van Nederland, 1913-1921* Amsterdam, Thesis Publishers.

-Brugmans, I.J. (1961). *Paardenkracht en mensenmacht. Sociaal-economische geschiedenis van Nederland, 1795-1940*. Den Haag, Martinus Nijhoff.

-Chow, G.C. (1960). Test of Equality Between Sets of Coefficients in Two Linear Regressions. Econometrica, Vol. 28, 3 (July), pp. 591-605.

-CPB (Netherlands Institute of Economic Policy Analysis) (1998), Groei arbeidsproductiviteit op sectorniveau en bedrijfstakniveau, *Centraal Economisch Plan 1998*, pp. 125-137.

-Crafts, N.F.R. (1985), *British Economic Growth During the Industrial Revolution*. Oxford: Oxford University Press.

- Crafts. N.F.R and G. Toniolo, eds. (1996), *Economic Growth in Europe Since 1945*, CEPR/Cambridge University Press

-David, P.A. (1990), The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox, *American Economic Review*, Papers and Proceedings, vol. 80, no.2, May, pp. 355-361.

-Freeman, C. and L. Soete (1987), *The Economics of Industrial Innovation*, 3rd edition, Pinter

-Goldin and Katz (1996), The origins of technology-skill complementarity, *NBER Working Paper no. W 5657*.

-Gordon, Robert J. (1999), U.S. Economic Growth since 1870: One Big Wave?, *American Economic Review* vol. 89 no. 2

-Griffiths, R.T. (1979). *Industrial Retardation in the Netherlands 1830-1850.* Den Haag: Martinus Nijhoff.

- Griliches, Z. (1994), Productivity, R&D, and the Data Constraint, *American Economic Review*, vol. 84, no. 1, pp. 1-23

-Groote, P. (1995), *Kapitaalvorming in infrastructuur in Nederland 1800-1913*. Capelle a/d/IJssel:Labyrint.

-Groote, P. , R.M. Albers and H.J. de Jong (1996). A standardised time series of the stock of fixed capital in the Netherlands. *Research Memorandum GD-25*. Groningen: Groningen Growth and Development Centre.

-Harberger, A.C. (1998), A Vision of the Growth Process, *American Economic Review* vol 88, no. 1

-Jong, H.J. de (1999). *De Nederlandse industrie 1913-1965. Een vergelijkende analyse op basis van de productiestatistieken*. Amsterdam: NEHA, series III, 29.

-Jonge, J.A. de (1976). *De industrialisatie in Nederland tussen 1850 en 1914*. Nijmegen: SUN Reprint.

- Jorgenson, D.W. and K. Stiroh (1999), Information Technology and Growth, *American Economic Review*, Vol. 89, No. 2, May, pp. 109-115.

-Kuznets, S. (1966). *Modern Economic Growth: Rate, Structure and Spread*. New Haven: Yale University Press.

-Lintsen, H.W., M.S.C. Bakker, E. Homburg, D. van Lente, J.W. Schot and G.P.J. Verbong (1992), *Geschiedenis van de techniek in Nederland. De wording van een moderne samenleving, 1800-1990* Zutphen, Stichting Historie der Techniek- Walburg Pers.

-Maddison, A. (1991), *Dynamic forces in capitalist development. A long run comparative view* Oxford/New York, Oxford University Press.

-Maddison, A. (1995), *Monitoring the world economy*. Paris, OECD.

-Meere, J.M.M. (1982). *De economische ontwikkeling en de levensstandaard in Nederland gedurende de eerste helft van de negentiende eeuw.* 's Gravenhage, Van Gennep.

-Minne, B. (1995), Onderzoek, ontwikkeling en andere immateriële investeringen in Nederland, *CPB Research Memorandum, No. 116,* The Hague.

-Mokyr, J. (1990), *The lever of riches: Technological creativity and economic progress* New York, Oxford University Press.

-Smits, J.P. (1999), Economische ontwikkeling 1800-1995, in: Ronald van der Bie and Pit Dehing, eds., *Nationaal goed. Feiten en cijfers over onze samenleving (ca.) 1800-1999* CBS, Voorburg and Heerlen/ Stichting Beheer IISG, Amsterdam.

-Smits, J.P., E. Horlings and J.L. van Zanden, *Dutch GNP and its components, 1800-1913* (Groningen Growth and Development Centre, forthcoming).

-Triplett, J.E. (1999), The Solow Productivity Paradox: What Do Computers Do to Productivity, *Canadian Journal of Economics* vol. 32, no. 2, April.

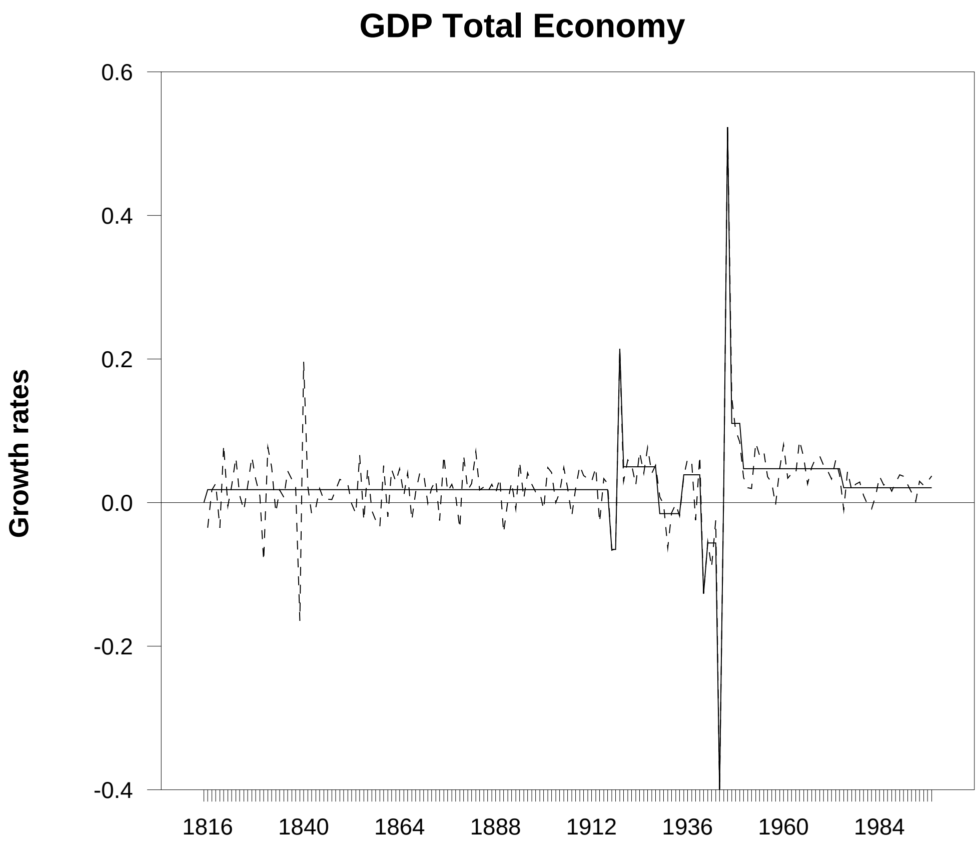
-Vries, Joh. de (1968). Economische groei en industrialisatie in Nederland 1850-1914, *Maandschrift Economie,* Vol. 33, 3, pp. 118-128.

- WRR (Scientific Council for Government Policy) (1980), *Plaats en toekomst van de Nederlandse industrie*, Staatsuitgeverij, 's Gravenhage.

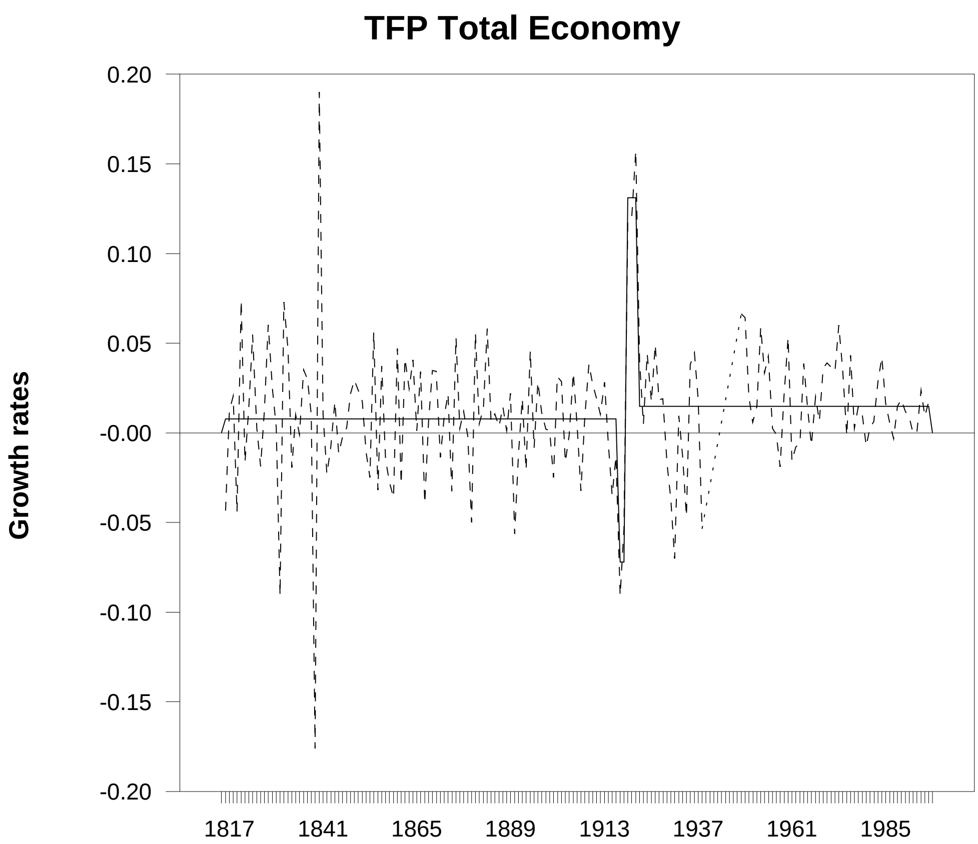
-Van Zanden, J.L. van (1988), *De dans om de gouden standaard. Economisch beleid in de depressie van de jaren dertig* Amsterdam, VU boekhandel/uitgeverij.

-Zanden, J.L. van and A. van Riel (1998), Surveying two centuries of Dutch growth, 1807-1990: institutional change, convergence and the steady state. Paper presented at the Groningen conference on *Productiviy and Standards of Living. Measurement, Modelling and Market Behaviour*, september 1998.

Appendix: Chow test results

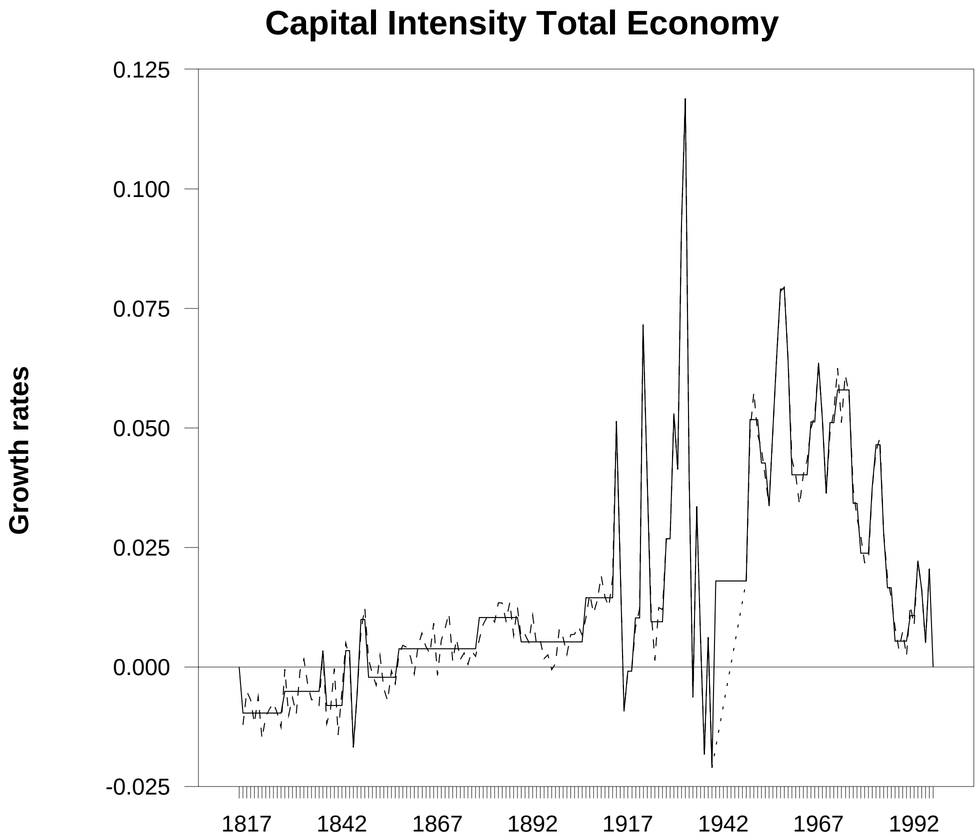


		Average growth	Std Error	T-Stat	Signif
1.	1816-1916	0.018135826	0.003270373	5.54549	0.00000011
2.	1917-1918	−0.065042197	0.023240366	−2.79867	0.00573160
3.	1919-1919	0.214497920	0.032866841	6.52627	0.00000000
4.	1920-1928	0.049824402	0.010955614	4.54784	0.00001034
5.	1929-1934	−0.015260100	0.013417832	−1.13730	0.25703239
6.	1935-1939	0.038919677	0.014698498	2.64787	0.00887154
7.	1940-1940	−0.126603208	0.032866841	−3.85200	0.00016640
8.	1941-1943	−0.056268484	0.018975680	−2.96529	0.00346429
9.	1944-1944	−0.399275023	0.032866841	−12.14826	0.00000000
10.	1945-1945	0.023337092	0.032866841	0.71005	0.47865772
11.	1946-1946	0.523576059	0.032866841	15.93022	0.00000000
12.	1947-1949	0.110710684	0.018975680	5.83435	0.00000003
13.	1950-1974	0.047197043	0.006573368	7.18004	0.00000000
14.	1975-1997	0.021046007	0.006853210	3.07097	0.00248920



		Average growth	Std Error	T-Stat	Signif
1.	1816-1916	0.007817706	0.003451315	2.26514	0.02478167
2.	1917-1918	−0.072054264	0.024526204	−2.93785	0.00376948
3.	1919-1921	0.131140196	0.020025561	6.54864	0.00000000
4.	1922-1996	0.014829148	0.004269464	3.47330	0.00065388

		Average growth	Std Error	T-Stat	Signif
1.	1816-1816	−0.048338744	0.033254672	−1.45359	0.14795866
2.	1817-1916	0.010048903	0.003325467	3.02180	0.00291360
3.	1917-1918	−0.058540478	0.023514604	−2.48954	0.01378184
4.	1919-1919	0.222886206	0.033254672	6.70240	0.00000000
5.	1920-1928	0.037931951	0.011084891	3.42195	0.00078394
6.	1929-1939	0.003834013	0.010026661	0.38238	0.70267021
7.	1940-1976	0.045785753	0.006175238	7.41441	0.00000000
8.	1977-1996	0.017325178	0.007435971	2.32991	0.02102163


Capital Intensity Total Economy
Growth rates
0.125
0.100
0.075
0.050
0.025
0.000
-0.025
1817
1842
1867
1892
1917
1942
1967
1992