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Can growth theory contribute to our understanding of nineteenth century economic dynamics?

The role of capital in economic growth in The Netherlands, 1850-1913*

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1 : INTRODUCTION

Capital has always held a prominent, but controversial, position in the academic discussion on economic growth. Ever since Robert Solow's model of growth (Solow 1956) has become the standard in neo-classical thought, it has been considered frustrating that the model is characterized by constant returns to scale ($\alpha+\beta=1$). Conceptually it has proved unsatisfactory that in the Solow-model continuous growth per head is only possible via some

Standard neo-classical growth model

$$Y = Ae^{\mu t}K^{\alpha}L^{\beta}$$

Y	gross domestic product
K	stock of capital (reproducible inputs)
L	labour (non-reproducible inputs or inputs in fixed supply)
A	constant, reflecting the technological starting position of society
e^{μ}	exogenous rate at which technology evolves
α	output elasticity of capital; $0<\alpha<1$: decreasing marginal returns to capital
β	output elasticity of labour; $0<\beta<1$: decreasing marginal returns to labour
$\alpha + \beta = 1$	

Note: a list of symbols may be found at the end of this paper

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exogenous determinant, such as population growth or technological progress. Empirically the Solow-model is unsatisfactory because it predicts a convergence in the growth pattern of economies that does not seem to take place.
Endogenous growth theories may be said to exist by virtue of these conceptual and empirical defects of standard growth-theory. These partly negative reasons for coming into being may explain why so many strands of new growth theory have been developed in a relatively short period. What they have in common is some endogenous engine of growth, which enables explanation of continuous growth from within the model. The formal expression of this may take many different forms, but it is still capital as a factor of production that plays the central role. In one of the first articles on what could then be called new growth theory Romer (1986) abandoned the assumption of decreasing marginal returns to capital. He assumed that spillovers from the stock of knowledge would create constant returns to capital ($\alpha=1$). This would also yield increasing returns to scale ($\alpha+\beta>1$).
Other authors have tried to abstain from the rather uncomfortable need to assume spill-over effects in order to come to a reasonable justification for constant marginal returns to capital. Many of them have introduced new factors of production in the production function, e.g. human capital, research & development outlays, and formal education. These extensions make it possible to include constant returns to broad capital in the growth model. This eventually led to Rebelo's formulation of endogenous growth (Rebelo 1991), which may be said (although semantically odd) to have become a classic in new growth theory (See Sala-i-Martin 1994,1).

Standard endogenous growth model

$$Y = A\tilde{K}$$

Y gross domestic product
$\tilde{K}$ stock of broad capital (all reproducible inputs)

In this paper we will try to shed some light on the role of capital in economic growth, adopting some of these theories. Starting from standard neo-classical growth theory, we will gradually progress to new theories of growth. Physical capital will play a prominent role in the analysis, but we will also pay attention to human capital.
Most attemps to lend new growth theories an empirical basis use cross-country comparisons. However, Pack (1994, 55) may be right in stating: "Unless there is some demonstration forthcoming that the theory is useful in explaining the growth pattern over time of national economies, it will remain a rich expansion of existing growth theory rather than a powerful organizing framework for thinking about actual growth phenomena." We therefore use new data on the national growth experience of The Netherlands 1850-1913. In the next paragraph we will give a brief description of the data employed.

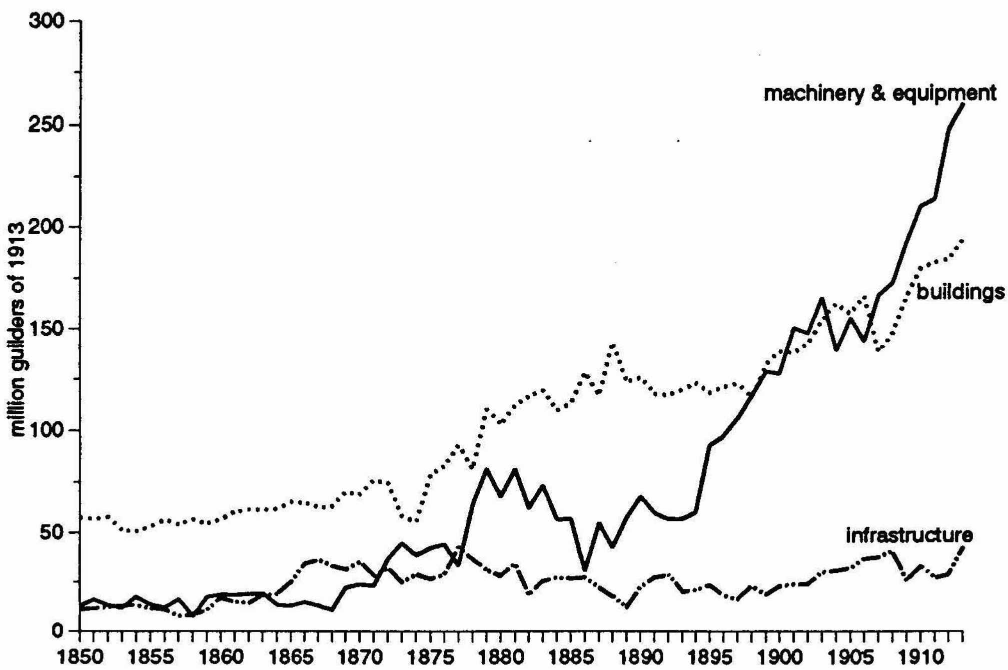
2 : DATA

The series on capital formation and capital stocks used here are the preliminary outcome of research on physical capital formation in The Netherlands 1800-1913 conducted by Ronald Albers (machinery & equipment), Adrian Clemens (buildings), and Peter Groote (infrastructure). The annual series on capital formation and capital stocks are subdivided by type of asset: machinery and equipment, buildings, and infrastructure. 'Machinery and equipment' includes cattle, vehicles, ships, etc. 'Buildings' includes both residential and non-residential buildings. 'Infrastructure' consists of transport networks, dykes, polders, telecommunications, and public utilities. This division by type of asset means, e.g., for railways that only the permanent way is attributed to infrastructure; the rolling stock forms part of machinery and equipment, and stations are grouped with buildings.

For a significant part the series on machinery, buildings and infrastructure were constructed 'bottom up', i.e. from data assembled at micro-level, usually the financial accounts of individual companies. To complement the estimates we used a variety of sources, most important of which are tax-data and official statistics. We applied the perpetual inventory method to calculate capital stocks.

Figure 1 shows gross fixed capital formation in machinery and equipment, buildings and infrastructure in constant prices. The rapid increase in investment in machinery after 1893

Figure 1 Gross fixed capital formation by type of asset, The Netherlands 1850-1913 (in millions of constant guilders of 1913)

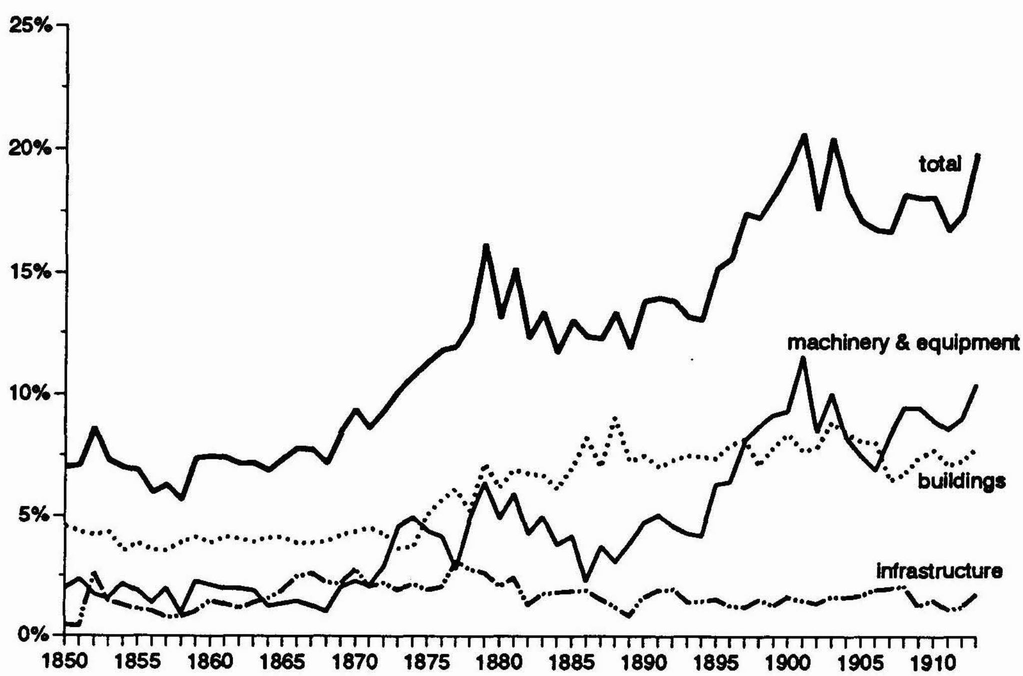


is striking. This series also has the most volatile character. Capital formation in buildings is more stable, albeit with a rising trend. Infrastructure, however, shows no clear trend, the most pronounced activity taking place in the period 1863-1881, mainly due to railway and canal building.
The gross capital stocks of the three types of assets show a more gradual development (Table 1). The stock of buildings remained the largest of the three, although its share declined gradually. Shortly after 1900 the gross capital stock of machinery and equipment overtook that of infrastructure.

Table 1 Development of the gross capital stock (constant prices; index, 1913 = 100). Share of each type of asset in the total stock, 1850-1913

	total stock	share of machinery & equipment	buildings	infrastructure
1850	21.7	5.4%	77.3%	17.3%
1860	25.9	5.5%	76.7%	17.7%
1870	32.3	5.9%	73.4%	20.6%
1880	42.7	11.1%	68.2%	20.7%
1890	56.1	14.3%	67.4%	18.3%
1900	69.4	15.8%	67.4%	16.9%
1910	91.2	20.8%	64.2%	15.0%
1913	100.0	22.9%	62.9%	14.2%

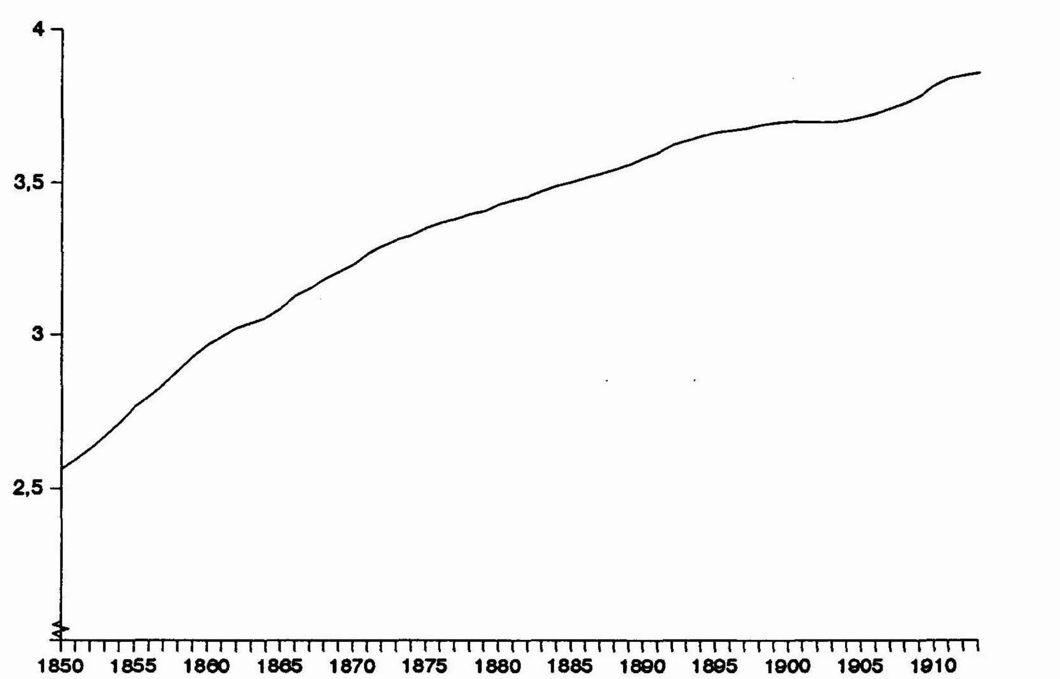
Figure 2 Investment ratio by type of asset and aggregate investment ratio, The Netherlands 1850-1913. Note: figures calculated from series in current prices



The series on GDP and GDP per capita used in this paper are the preliminary outcome of the project 'Reconstruction of Dutch National Accounts 1800-1913', to which our research is linked.[1] These new annual data on Dutch national income enable us to calculate the investment ratios per type of asset and for the three types of assets taken together (Figure 2). The aggregate investment ratio increased profoundly from 6% around 1850 to approximately 20% around 1913. The late 1870's and the turn of the century stand out as periods of increased investment activity relative to national income.

In our opinion human capital is tied to people. Assuming the lifetime of humans (and therefore the lifetime of their human capital) to be finite, we can apply the perpetual inventory method to build a stock of human capital in essentially the same way as the stocks of physical capital. Our estimate is based on data on the total number of pupils receiving primary education. From these cumulative annual data we calculated total years of schooling

Figure 3 Stock of total years of schooling present in the working age population (12-65), per head of total population, The Netherlands 1850-1913



present in the working age population. An individual's human capital (six years of schooling) enters the stock when he finishes school and leaves the stock when he reaches the age of 65 or at death. For the survival rate between the ages of 12 and 65 we applied demographic key figures. Figure 3 shows the development of the human capital stock per head of total population. This measure of human capital focusses on formal education and ignores for example on the job training.

1 We would like to thank our colleagues of the project for kindly providing us with their new GDP-series. For a brief introduction, see Horlings, Smits & Van Zanden (1993). Population figures from Horlings (1993).

3 : ANALYSIS

As stated in the introduction, we will try to derive insight into the long term dynamics of economic growth from different types of growth theory. We will adopt a standard neo-classical viewpoint, a conservative variant of new growth theory in which physical capital still holds a central position, and a model with human capital.

Abramovitz (1993) states that physical capital played a more prominent role in the nineteenth century than today. Technological progress had a strong capital-using bias. Only in the twentieth century does intangible (human) capital come to the forefront. Within the framework of neo-classical theory the role of physical capital can be analysed by means of growth accounting. When measuring over 'long swings'[2] in the nineteenth century, Abramovitz finds the contribution of physical capital to American economic growth to be far greater than the contribution of technological progress (measured as the residual after subtracting the contributions of capital and labour). After 1870 the accumulation of physical capital became less dominant a source of growth, but until the turn of the century its contribution remained important. Only then did the picture that is familiar from modern growth accounts arise: a contribution of physical capital to growth of about 20%.[3] When Abramovitz adopts a periodisation that stretches over 'long periods'[4] instead of 'long swings' his conclusion does not change: "... the sources of growth are quite at variance with the twentieth century results. It finds that the growth of capital intensity was a much larger source of labour productivity growth in the nineteenth century than in the twentieth." (Abramovitz 1993, 223).

We will investigate whether the same conclusion can be drawn for The Netherlands in the period 1850-1913 by means of a analogous exercise in growth-accounting. We approximated the growth of the labour force by using the growth rate of the population. Capital and labour were weighed with their shares in national income in 1850, 1880 and 1913. We used income shares given in Horlings, Smits & Van Zanden (1993, 4).[5] Profit income must be divided between capital and labour (Pilat 1993, 50). We opted for equal shares. Table 2 presents the

Table 2 Contributions to GDP growth, percentages per year, The Netherlands 1850-1913

	Capital	Labour	Residual
1850-1913	51.0%	23.3%	25.7%
1850-1880	64.7%	15.8%	19.5%
1880-1913	46.8%	27.9%	25.3%

2 The term is Abramovitz'. He discerns the following 'long swings': 1800-1835, 1835-1855, 1855-1871, 1871-1890, 1890-1905, 1905-1927, 1929-1948, 1948-1966, 1966-1989 (Abramovitz 1993, table 2).

3 See in particular Maddison (1987).

4 He defines his 'long periods' as follows: 1800-1855, 1855-1890, 1890-1927, 1929-1966, 1966-1989 (Abramovitz 1993, table 1).

5 Unfortunately, income shares were measured in NDP instead of GDP. Therefore, the contribution of capital to growth will be underestimated.

results. It is clear that the growth of the capital stock is the single most important driving force behind the growth of GDP. This confirms Abramovitz' view. The contribution of labour is more or less in line with present-day results. The residual is relatively small, especially in comparison with most growth accounts for the twentieth century. This leaves only a limited role for disembodied technological progress, better resource allocation, etc. It is possible to include human capital accumulation in the growth accounts. We applied an augmented Solow model with human capital as an additional factor of production. In order to asses the weights for the factors of production, we followed the same procedure as in the earlier growth account. The portion of profit income previously allocated to labour must now be assigned to human capital. In accordance with Mankiw, Romer & Weil (1992), we constrained the shares of wage income so as to arrive at equal shares for raw labour and human capital. The inclusion of human capital in the growth accounting does not change the general picture: it is physical capital that mainly 'caused' economic growth in the nineteenth century. It appears that the contribution of human capital is more important than that of raw labour. Furthermore, the introduction of human capital squeezes the residual.

Table 3 Contributions of physical capital, human capital, labour, and the residual to GDP growth, percentages per year, The Netherlands 1850-1913

	physical capital	human capital	raw labour	residual
1850-1913	51.0%	18.6%	11.6%	18.7%
1850-1880	64.7%	16.7%	7.9%	10.7%
1880-1913	46.8%	17.8%	13.9%	21.4%

It is tempting to perform an exercise that goes the other way round. Instead of using a given production function to try to calculate the contribution of the different factors of production, one could try to estimate the production function itself, starting from data on factor inputs. Such an exercise would be analogous to what Mankiw, Romer & Weil (1992) did on a cross country basis. However, in order to do so on time series or panel data, it is necessary to include annual data on the rate of technical progress in the estimation.[6] The results would be seriously flawed —or, in fact, unusable— if these were simply imposed.

If we extend the neo-classical framework in the direction of endogenous growth theories, one of the key insights is that capital accumulation influences technological progress, and thereby long term growth. Considering the results of the growth accounting exercises performed earlier, it seems fruitful to apply a conservative variant of endogenous growth theory (i.e. the Romer (1986) model based on aggregate capital and spill-overs) in order to assess the insights that new growth theory might add to historical analysis. Therefore, we will review Arrow's extension of the standard neo-classical growth model (Arrow 1962) and Romer's further elongation of this into the realms of endogenous growth (Romer 1986). In these models physical capital still plays the leading part, but intangible capital, i.e. knowledge, is

6 Since Mankiw, Romer & Weil used the growth performance of a sample of countries over the period 1960–1985, they also needed a measure of the rate of technical progress. They adopted an aggregate estimate of the annual rate of technological progress of two percent over the whole period (Mankiw, Romer & Weil 1992, 412–413).

introduced as a force working against decreasing returns to physical capital. Arrow's basic statement is that labour productivity does not only depend on the size of the capital stock and an exogenously defined level of technology, but also on experience gained in the process of production. Investment generates changes in the environment of production that pose new problems. These problems are gradually solved by a mechanism of learning that is inherent in using the new machines and applying the new processes. This mechanism is referred to as 'learning by doing'. Also, changes in the environment may stimulate people to find new ways of further improving the process of production. These factors increase labour productivity over and above the effect of the investment itself. Consequently, part of the increase in labour productivity is no longer exogenous, but endogenous. Arrow stays within the boundaries of the Solow-model by maintaining the assumption that 'learning' is a public good. The stock of knowledge existing in the aggregate economy is nonrival and nonexcludable. Individual entrepreneurs may use it without costs and without depriving compatitors the benefits of it. Therefore, labour productivity depends on experience gained from activities in the entire economy. The appliance of this knowledge may be regarded as an externality to the individual company. At the company level, standard neo-classical theory is still valid, and companies can act accordingly. At the aggregated level, the effects depend on the size of the externality compared to the diminishing returns to capital. In standard economic theory no *a priori* reasons exist for believing one or the other is the larger. It depends on one's position in the discipline, on the arguments raised, and on the purpose of the study, whether it is assumed that the externalities or the diminishing returns are the more important. In Arrow's view, the spillovers from the stock of knowledge do not compensate for the diminishing returns to capital.

Romer took a small step that proved to be of importance. He assumed that the spillovers from the stock of knowledge are large enough to fully compensate for the decreasing marginal returns to capital. His arguments are partly based on historical experience. Growth rates were much lower in the past than they are at present. Thus, the process of economic growth seems to evolve in time. In Romer's view, technological development cannot be the only source of this, since poorer countries nowadays seem to grow slower than richer countries, although the technological possibilities open to them ought to be the same. The growth of the stock of knowledge that is still partly brought about unintentionally (as a side effect of investment) is now larger than the growth of the capital stock.[7] According to him decreasing marginal returns to capital are offset by these spillovers, and the process of economic growth has an endogenous component.

In the views expressed above, whether in Arrow's version or in Romer's, the spillovers are interlinked with investment. It seems plausible that it is machinery investment that plays the key role in this. Investment in infrastructural works and in buildings is likely to play a more modest role in the process, since these capital goods have a much longer lifetime and a slower rate of technological development.[8] Therefore, we expect the association between GDP growth and machinery investment to be stronger than between GDP growth and other types of investment. Of course, other reasons may be put forward to explain this. For example, the rate of embodied technological progress will also be greater in machinery than

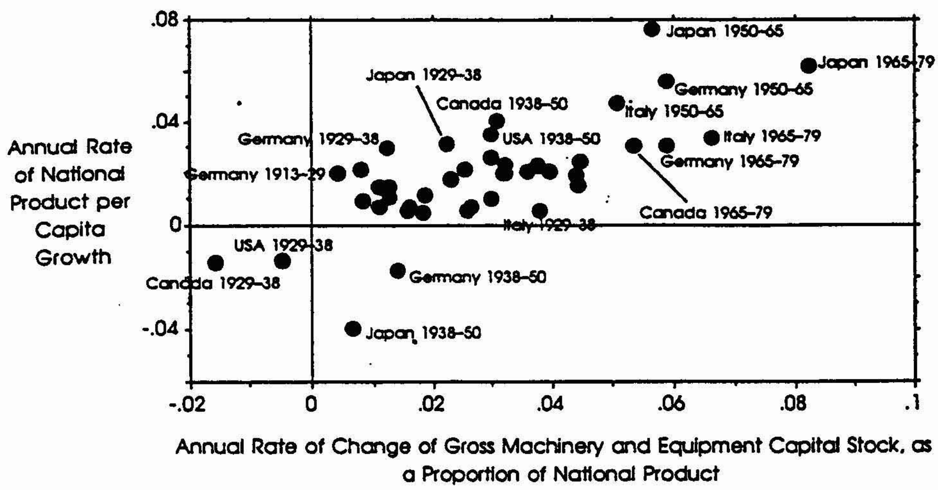
7 In fact, Romer (1986) also introduces forms of knowledge that are produced intentionally. At least partly, these must be excludable and rival. Yet, the form of knowledge produced as a side effect of economic activity (i.e. through the learning by doing mechanism) is still nonrival.

8 We do not want to suggest here that infrastructural and building investment is unimportant in the process of growth, nor that they do not play a role in the transmission of spillovers.

in infrastructure and buildings. The structural changes in the economy that have occurred since the Industrial Revolution may have increased the relative importance of machinery investment in economic growth. Yet these arguments only strengthen our case: machinery investment ought to show a stronger association with economic growth per head than infrastructural or building investment. If this phenomenon is not discernible, doubts may be raised against the notion that learning by doing effects are an important factor in economic growth.

De Long (1992), and De Long & Summers (1991) tried to prove that the expected relationship does in fact exist. Although at first sight their tests seem convincing, it is disappointing that they need the growth experiences of several countries over rather long periods (15 years), instead of national ones. We followed De Longs (1992) procedure. He regressed the growth rate of per capita GDP [g(Y/P)] on the growth rate of the capital output ratio

Figure 4 Relation between g(Y/P) and g(Y/K) for machinery; sample of 6 countries, 1870–1980

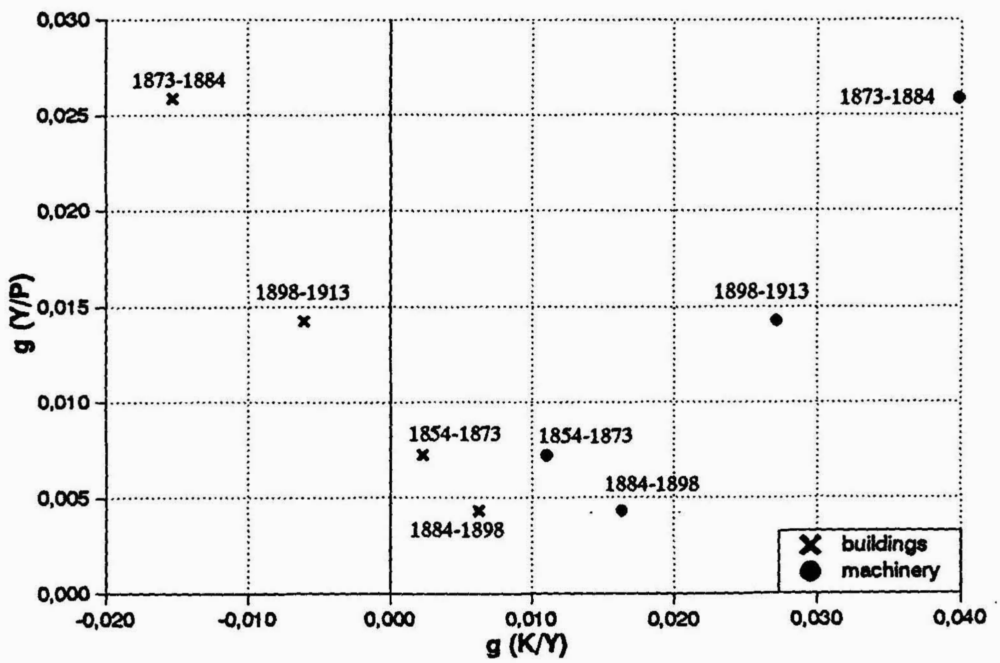


source: De Long (1992, 311)

[g(K/Y)]. At first sight the independent variable may seem odd, in that the capital stock is divided by output. However, the growth rate of the aggregate capital-output ratio has an interpretation which follows directly from the Solow-model. Consider the standard production function with two factors of production, introduced in the first paragraph. It can be shown that this equation is equivalent to: $(\Delta Y/Y - \Delta L/L) = (\mu/1\text{-}\alpha) + (\alpha/1\text{-}\alpha) \times (\Delta K/K - \Delta Y/Y)$. This can be interpreted as a rise in the capital–output ratio being necessary for economic growth per head. The results obtained by De Long are shown in Figure 4. We see a fairly strong association between GDP growth and machinery investment, nearly all observations turning up in the upper right (+/+) or lower left (-/-) quadrants.

For The Netherlands we extended his analysis to investment in buildings and infrastructure. We slightly adjusted De Longs periodisation to follow the Dutch business cycle more closely.[9] Figure 5 shows the results of this exercise. According to De Long one would expect a strong positive correlation between growth in GDP per capita and the growth of the capital stock in machinery and equipment (De Long 1992, 310). The relationship with other forms of capital formation should be less pronounced. All observations for machinery indeed

Figure 5 Relation between g(Y/P) and g(K/Y), machinery & equipment and buildings, The Netherlands 1850-1913



turn up in the right quadrant, although the outcome is sensitive to the choice of subperiods. In our calculations for The Netherlands 1850-1913 the coefficient on the growth rate of K/Y for machinery and equipment is 0.717.[10] This result fits in with De Long's estimates (De Long, 1992, 312). However, if we follow De Long's own periodisation the observations for machinery and equipment become more widely scattered. The period 1851-1870 even turns up in the 'wrong' quadrant, a negative growth rate of the capital-output ratio being associated with positive GDP growth. To gain more insight in the measure, we extended the analysis to Great-Britain in the period 1850-1913 and The Netherlands 1950-1989. These calculations also show a less robust relationship between machinery investment and per capita GDP growth, with e.g. the UK 1885-1900 turning up in the -/+ quadrant.[11] The

9 De Long uses the subperiods 1870-1885, 1885-1900 and 1900-1913. Instead, we opted for 1854-1873, 1873-1884, 1884-1898 and 1898-1913.

10 R^2 = 0.91; t-value: 4.41; d.f.: 2.

11 Relation between g(Y/P) and g(K/Y), machinery and equipment.

Country	Period	$g(K_M/Y)$	g(Y/P)
UK	1870-1885	0.011	0.009
UK	1885-1900	-0.004	0.029

(continued...)

resulting pattern for machinery investment does not always fit in nicely with the other results plotted in De Long.
At first sight, the positive association between machinery investment and income growth supports the validity of a subdivision of capital by type of asset. This conclusion is reinforced since it turns out that the growth rate of the capital-output ratio for infrastructure and buildings is in fact negatively correlated with GDP growth. However, the negative correlation between g(K/Y) and g(Y/P) for buildings and infrastructure may be an artifact of the long service lives of these assets which causes the capital stock to be relatively stable. GDP is far more volatile than the capital stocks of buildings and infrastructure. Since GDP appears on both sides of the equation this results in a negative correlation between the growth rate of capital stock/GDP and the growth rate of GDP per capita. This conclusion also applies to the aggregate capital stock, which is dominated by buildings. The capital stock of machinery, however, is more volatile. Therefore, the artifically strengthened correlation refferred to above is less prominent. Even though the measure used by De Long is not entirely transparent, indications are that the relationship between GDP growth and machinery investment does differ from the one between GDP growth and investment in other types of assets. Learning by doing may well be partly responsible for this difference in behaviour.
There are two possible ways to augment our analysis. First, we might try to perform a regression on annual data. Second, we can introduce other variables. Prior to running the regressions it is necessary to check the time series properties of the variables used. We carried out unit root tests to establish whether the time series are stationary. Table 4 reports augmented Dickey-Fuller t-statistics and critical values. For most of our series the t-statistics

Table 4 Results of unit root stationarity tests (N = 63)

	Dickey-Fuller t-statistic
g(Y/P)	-9.3608
$g(K_M/Y)$	-6.8363
$g(K_B/Y)$	-8.6959
$g(K_I/Y)$	-8.7672
$g(I_M/P)$	-7.0911
$g(I_B/P)$	-6.5563
$g(I_I/P)$	-6.3255
$g(K_M/P)$	-2.7217
$g(K_B/P)$	-3.4190
$g(K_I/P)$	-1.9966
g(H/P)	-1.8830

MacKinnon critical values		
1%	5%	10%
-3.5398	-2.9092	-2.5919

11 (...continued)

UK	1900-1913	0.016	0.019
Netherlands	1950-1965	0.055	0.047
Netherlands	1965-1979	0.004	0.039

Figures for The Netherlands 1950-1989 from CBS-data. For the UK we used the latest revision of Feinstein's capital stock estimates (1988, 435), instead of De Long who employed the older figures presented in Feinstein (1972). In general, De Long's data for some countries are difficult to trace, mainly due to unclear annotation. For example, his capital stock figures for the United States were 'derived from' Kuznets (1961) (De Long 1992, 310, note 11). However, Kuznets (1961) does not present the relevant stock data.

exceed at least the 10% critical values, and thus the series can be considered stationary. However, if we use annual data, short-term fluctuations complicate the analysis. They obscure possible long-term relations between our variables. Because of the volatility of income and investment, regressions on annual data do not yield significant results. It is necessary to use longer periods to eliminate most of the disturbances. An inherent disadvantage of this procedure is, however, that the number of observations diminishes and that few degrees of freedom remain. In our case the necessity to use longer periods rules out the possibility of multiple regression.

We can also introduce other variables. For example, it may be better to consider the growth rates of the (disaggregated) capital stocks themselves, rather than the indirect measure of the capital-output ratio. Going one step further, in Arrow's theory of learning by doing it is not the capital stock that plays the central role, but investment. Finally, we can include human capital in the analysis.

Regressions on the growth rates of investment do not yield positive results, even when measured over longer subperiods. The alternative is to regress the growth rate of per capita GDP on the growth rates of the capital stock per capita, for the various subsets of capital. Unfortunately, these regressions also yield inconclusive results. The coefficient of determination is low and the coefficients on the growth of the capital stocks are not statistically significant. Inclusion of human capital in the regressions does not improve the outcome either.

The disappointing conclusion must be that a significant relationship between machinery capital and GDP can only be discerned if De Long's measure of the capital-output ratio is applied. For other variables, which would be theoretically closer to the concept of learning by doing, a significant positive relationship with GDP growth cannot be confirmed by linear regression.

4 : CONCLUSIONS

In this paper we have taken a pragmatic stance towards growth theory: how can it, i.e. both neo-classical and new growth theory, contribute to our understanding of economic growth processes in the past?

First, we considered neo-classical growth theory. For the twentieth century most growth accounts show a large 'residual', the exact meaning and contents of which are still subject of debate. For The Netherlands in the period 1850-1913 we found the residual to be much smaller. Growth of physical capital turned out to be the single most important contributor to economic growth. These outcomes are in line with those of Abramovitz for the USA in roughly the same period. The extension of the analysis by adopting an augmented Solow-model with human capital as an additional factor of production does not radically change the picture. Physical capital is still the main driving force behind economic growth. The contribution of human capital appears to be larger than that of raw labour.

Second, we looked at endogenous growth theory. On the whole it turned out to be rather difficult to make endogenous growth theory operational. A practical, but no less real, difficulty for historical applications is the lack of data. Even when available, data are often limited in scope and possibly flawed. For example, the gathering of historical data on human capital is still in its infancy. Along the lines of Romer and Arrow we therefore selected a conservative variant in which endogenous components of economic growth are linked to physical capital. In this variant spillovers from the stock of knowledge in the form of learning by doing give an extra stimulus to economic growth. The idea is that the effects of learning by doing are connected in particular with machinery investment. Therefore, our analysis focused on disaggregated capital. Our hypothesis was that the correlation between output growth and investment in machinery is higher than that of output growth and investment in other types of assets. This hypothesis can only be tested in a negative way. Even if the correlation between output growth and investment in machinery indeed turns out to be the strongest, this does not necessarily imply an endogenous cause. Other factors, which still fit into the framework of traditional growth theory, e.g. embodied technological progress, may accomplish the same effect.

The notion that learning by doing was both important and linked to investment in machinery cannot be conclusively confirmed. Following De Long our research suggests that machinery investment does behave differently from other types of investment. Learning by doing may well have been responsible for this. Formal testing of the relationships between various types of capital and GDP growth using national time series data proved to be difficult, however. Various factors may be held responsible. In the first place, data related problems may have blurred the picture. In the second place, the relationship between the variables may not be linear or stable over time. And, finally, short-term fluctuations may disturb any long-term relationship. This last drawback is especially damaging when using national time series data as opposed to cross country analysis.

To paraphrase Pack's statement cited in the first chapter: the demonstration that new growth theory is useful in explaining the growth pattern over time of national economies is still 'forthcoming'.

5 : LIST OF SYMBOLS

Y	gross domestic product
P	population
K_j	gross stock of physical capital of asset j
I_j	gross fixed capital formation of asset j
H	gross stock of human capital of asset j
L	labour
A	a constant, reflecting the technological starting position of society
e^{μ}	exogenous rate at which technology evolves
α	output elasticity of capital
β	output elasticity of labour

subscript j denotes types of assets:

M	machinery and equipment
B	buildings
I	infrastructure

subscript t denotes time (years)

prefix g denotes annual compound growth rate

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