OLIGOPOLISTIC COMPETITION AND ECONOMIC DEVELOPMENT[1]

ADRIAN MOONS

Entrepreneurs leave profit in the market in order to get a higher profit. They give up profitable production which yields marginal revenues above marginal costs. Schumpeter's paradox of entrepreneurial behaviour, which goes beyond rational economic action, is reformulated. There are "hidden" levels of efficient production which cannot be discovered by neoclassical profit maximization. The correspondingly higher profit levels ask for entrepreneurship. Once discovered they give rise to oligopolistic competition and enable entrepreneurial firms to get market power over firms that continue to produce in accordance with the neoclassical theory.
The theory has empirically been applied to the manufacturing industry of the United States, Germany, France and the United Kingdom over the periods 1960-1993 and 1975-2018. Schumpeterian firms appear to have greatly increased their market share in the US, Germany and the UK, especially after 2000. In France, however, Schumpeterian firms started to expand their market share already twenty years earlier but apparently they clearly lose competitiveness after 2000.
These different figures are obtained within a feasible production technology which turns out to be basically the same across the four discerned countries.

Keywords: entrepreneur, efficient production, oligopolistic competition.

1. INTRODUCTION

If economists could predict market prices and evaluate, thoroughly, all the new products and production processes which technical engineers are continuously inventing, then in formulae expressed rationality would enable them to determine which new combinations yield the largest excesses of marginal revenues above marginal costs over time. So, it was thought, entrepreneurs would no longer be needed to perform this task. Wrestling with the place of entrepreneurship in economic theory Baumol has stressed that the neoclassical model of the firm is "essentially an instrument of optimality analysis of well-defined problems, and it is precisely such (very real and important) problems which need no entrepreneur for their solution" (Baumol, 1968, p. 67).

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[1] This paper contains a revision of, in particular, paragraphs 4 and 5 of the paper of the same name published in 1996 as OC*f*EB Research Memorandum 9611, Erasmus University Rotterdam (presented at EEA-ESEM congress, Istanbul).

In describing the variety of new products and production processes, the endogenous growth theory is still based on such an analysis in which profit maximization follows from equalizing marginal costs and marginal revenues. Not surprisingly, Baumol has repeated that the neoclassical "theory, as it has developed, offers no promise of being able to deal effectively with the description and analysis of the entrepreneurial function. For maximization and minimization have constituted the foundation of the theory, and as a result of this very fact the theory cannot provide an analysis of entrepreneurship". "At least until recently", Baumol adds, "there was little sign of breakthroughs in this area" (Baumol, 1993, p. 14).
This paper challenges this view. Entrepreneurship in formal analysis emerges as soon as one restriction of the neoclassical theory is broken up. Equipped with Schumpeter's crowbar, hardened by an analysis of stationary states, it appears a rather simple task.

The next two sections provide the theoretical foundation by showing how entrepreneurship may develop in an economy with some gradual innovation, allowing oligopolistic competition to emerge quite naturally. The vintage model which describes a stationary state not only shows how Marshallian firms could think to maximize their profits by equalizing marginal costs and marginal revenues, but also how Schumpeterian firms may attain higher levels of efficiency. The most profitable lifetime of machinery, derived in section 3, appears to be independent of wages and prices and therefore usually deviates from the neoclassical economic lifetime.
Under the restriction that the feasible production of both all Marshallian and Schumpeterian firms is close to but always higher than the actual production and that the necessary labour places also nicely correspond with the actual employment, section 4 completes the model of feasible production with an investment equation that in view of the above restrictions by iteration interprets which division of investments between Marshallian and Schumpeterian firms can best explain actual investments. This section also alludes to the oligopolistic competition that results from the interaction between Schumpeterian and Marshallian firms. Schumpeterian firms have the ability to set both wages and prices. Section 5 gives the empirical results of an application to the manufacturing industry of the United States, Germany, France and the United Kingdom. Section 6 links up with the literature from which oligopolistic competition turns out to

be the driving force behind economic development. It also indicates lines of further research. Conclusions are given in section 7.

2. FEASIBLE PRODUCTION

The emergence of entrepreneurship as an independent factor of production follows from an analysis of a stationary economy which consists of *n* firms, each of them being described by one and the same vintage model.

Suppose that each firm uses vintages of investment $i_{t,\tau}$, where t indicates the actual year and τ the year t-τ in which the vintage was installed, and that this investment grows at a yearly rate equal to π. Suppose further that every year a fraction δ ($\delta \geq 0$) of the machinery $i_{t,\tau}$ installed in year t-τ can no longer be used as a result of physical deterioration and, moreover, that the production capacity of each vintage $y_{t,\tau}^*$ depends on a capital output ratio κ_t, which changes every year with a capital augmenting rate of λ for embodied capital that remains fixed after installation next to a disembodied rate $d\lambda$ that affects all installed vintages equally in year t. The production capacity of one vintage $y_{t,\tau}^*$ is than determined by

$$y_{t,\tau}^* = \frac{1}{\kappa_t} i_{t,\tau} = \frac{(1+d\lambda)^t (1+\lambda)^\tau}{\kappa} \frac{(1-\delta)^\tau}{(1+\pi)^\tau} i_{t-\tau}.$$

Suppose also that α_t denotes the labour intensity of the production which decreases with an embodied rate μ (μ>0) and a disembodied rate $d\mu$. The labour places of a vintage are then equal to

$$a_{t,\tau}^* = \frac{\alpha_t}{\kappa_t} i_{t,\tau} = \frac{\alpha(1+d\mu)^t (1+\mu)^\tau (1+d\lambda)^t (1+\lambda)^\tau}{\kappa} \frac{(1-\delta)^\tau}{(1+\pi)^\tau} i_{t-\tau}.$$

Before we define the production capacity y_t^* and the labour places a_t^* of all M vintages used by each firm we simplify the formulae by substituting their parts that are equal to all vintages, which implies $\frac{\kappa}{(1+\lambda)^t (1+d\lambda)^t} = \kappa_t$ and $\alpha(1+\mu)^t (1+d\mu)^t = \alpha_t$. Moreover, we simplify the model by assuming compound growth calculation over the smallest possible time units[2].

[2] In the empirical analysis we continue to use time units equal to whole years.

Then the summation of all *M* vintages results in[3]

$$y_t^* = \int_{\tau=0}^{M} \frac{1}{\kappa_t} i_{t-\tau} e^{(\lambda-\pi-\delta)\tau} d\tau = \frac{i_{t,t}}{\kappa_t(\lambda-\pi-\delta)} (e^{(\lambda-\pi-\delta)M} - 1) \qquad (1)$$

and

$$a_t^* = \int_{\tau=0}^{M} \frac{\alpha_t}{\kappa_t} i_{t-\tau} e^{(\lambda+\mu-\pi-\delta)\tau} d\tau = \frac{\alpha_t i_{t,t}}{\kappa_t(\lambda+\mu-\pi-\delta)} (e^{(\lambda+\mu-\pi-\delta)M} - 1). \qquad (2)$$

Usually, firms maximize profit p_t,

$$p_t = py_t\left(y_t^* - i_{t,t}\right) - w_t a_t^*, \qquad (3)$$

in which py_t and w_t represent the production prices and wages. The investment prices are assumed to be equal to the production prices.

Substitution of (1) and (2) into (3) results in

$$p_t = \frac{py_t i_{t,t}}{\kappa_t(\lambda-\pi-\delta)}(e^{(\lambda-\pi-\delta)M} - \kappa_t(\lambda-\pi-\delta) - 1) - \frac{w_t \alpha_t i_{t,t}}{\kappa_t(\lambda+\mu-\pi-\delta)} (e^{(\lambda+\mu-\pi-\delta)M} - 1).$$

The first order condition for a maximum

$$\frac{\delta p}{dm} = \frac{py_t i_{t,t}}{\kappa_t} e^{(\lambda-\pi-\delta)M} - \frac{w_t \alpha_t i_{t,t}}{\kappa_t} e^{(\lambda+\mu-\pi-\delta)M}$$

implies

$$py_t - w_t \alpha_t e^{\mu M} = 0.$$

The resulting economic lifetime M_t^{eclt},

$$M_t^{eclt} = \frac{1}{\mu}(lnpy_t - lnw_t - ln\alpha_{tt}),$$

appears to depend on the prevailing wages and prices[4].

The second order condition is fulfilled because

$$-\mu w_t \alpha_t e^{\mu M} < 0.$$

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[3] The model is held as simple as possible. The capital augmenting development could be made even more endogenously by allowing firms to produce either consumption or investment goods. The labour productivity embodied in new investment goods, for instance, may rise more strongly as their producers invest more in human capital. See Romer (1990). Moreover, the model may also enable to discern radical product and process innovation. This turns out as soon as one or more firms start to produce with an entirely new set of coefficients (α, μ, κ, λ). Agion and Howitt (1992) describe growth through creative destruction while using a monopolistic competition framework to introduce newly innovated intermediate goods. Segerstrom et al. (1990) use a similar framework to describe product innovation, unequally spread among regions. It is also applied by Amable (1992) who has brought both types of innovation into one model.
The simple model here only serves to elucidate the emergence of oligopolistic competition and its driving forces. It constitutes a framework which is intended to replace just the monopolistic competition framework. Thereafter, it could benefit from the inspiring ways innovation is modelled in recent literature.

[4] As easily can be seen, the same economic lifetime also follows from the neoclassical condition that vintages will be kept in operation as long as marginal revenues exceed marginal costs. This implies for the oldest vintage in operation $py_t y^*_{t-M_t^{eclt}} = w_t a^*_{t-M_t^{eclt}}$.

The above vintage model could also be used to describe the stationary economy which consists of the *n* firms as a whole. If its labour supply A_t grows at a yearly rate ρ, the total investment which generates full employment in this economy follows from a reformulation of (2).

$$i_{t,t}^{eclt} = \frac{\kappa_{tt}(\lambda+\mu-\pi-\delta)A_t}{\alpha_{tt}(e^{(\lambda+\mu-\pi-\delta)M_t^{eclt}}-1)} \qquad (5)$$

With the saving rates over capital and labour income equal to σ_c respectively σ_l the equality of savings and investment

$$i_{t,t}^{eclt} = \sigma_c\left(y_t^* - \frac{w_t}{py_t}A_t\right) + \sigma_l\frac{w_t}{py_t}A_t$$

implies a real wage rate w_t/py_t

$$\frac{w_t}{py_t} = \frac{i_{t,t}^{eclt}-\sigma_t y_t^*}{(\sigma_l-\sigma_c)A_t} \qquad (6)$$

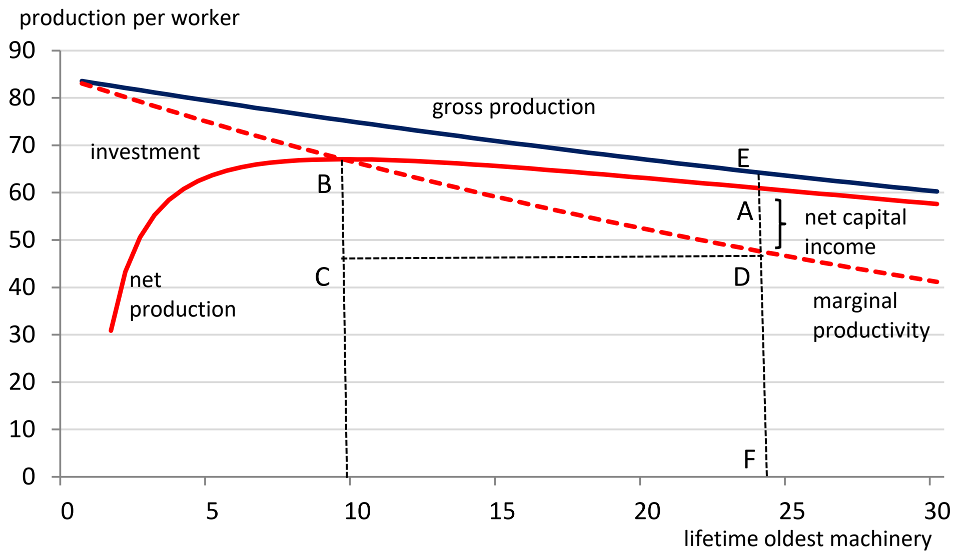
So, the stationary state is completely determined. The production may be called efficient: given both the available labour and the capital formation following from the saving rates there is no way to produce more efficiently. Additional figures could easily be derived, such as the rate of return on investment r_t^{eclt}. This rate follows from the profits p_t, as described by (3) and the labour supply A_t, over the capital formation which could be derived from (1). Hence

$$r_t^{eclt} = \frac{1}{\kappa_t} - \frac{(\lambda-\pi-\delta)(py_t i_{t,t}^{eclt}+w_t A_t)}{py_t i_{t,t}^{eclt}(e^{(\lambda-\pi-\delta)M_t^{eclt}}-1)}.$$

So far, it is all quite familiar, as is the next step, following Solow's track. He rightly points out that "if there are two initially identical economies and one of them succeeds in consuming less of its output than the other, then after some lapse of time the return on investment will be lower and real wages higher in the high-saving economy than in the low-saving economy" (Solow, 1963, p. 36). The higher the saving rates and the higher the real wages, the lower will be the economic lifetime.

So, we can order all stationary economies according to their economic lifetime. Each slice of figure 1 (see also Van Schaik, 1978, p. 276) represents a Solow type of a stationary economy in which the production can be called efficient in view of the available labour and capital. The successive slices show, as Solow says, an increasing wage share and a diminishing share of net capital income AD in the net production along with an increase in saving and investment[5].

Figure 1
Gross and net production per worker and his marginal productivity in stationary states classified after the lifetime of the oldest machinery in use



The figure reflects the estimated production technology of US manufacturing industry in 1997 (current prices, $ thousand)

3. EFFICIENT PRODUCTION

Among all those stationary economies there is, however, one economy in which the net production reaches an absolute maximum. The lifetime which belongs to this stationary economy, the most profitable lifetime M_t^{mplt}, could also be derived from a maximization of profit function (3). However, to do so, we have to recognize the restriction imposed by the limited available labour. In case of full employment the following reformulation of (5) must hold

$$i_{t,t}^{mplt} = \frac{\kappa_{tt}(\lambda+\mu-\pi-\delta)A_t}{\alpha_t(e^{(\lambda+\mu-\pi-\delta)M_t^{mplt}}-1)} \qquad (7)$$

Substitution of (1) and (7) into (3) yields

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[5] Appendix A further elaborates the relation with the Solow growth model. It graphically shows the tendency towards a steady state for any saving rate. It also investigates the optimal saving rate. The figure for the resulting Golden Rule of Accumulation is compared with both figure 1 and the most profitable lifetime as explained in the next section. In addition the appendix stipulates that oligopolistic competition may be of more importance for economic development than policies aimed at an optimal saving rate.

$$p_y = py_t\left[\frac{(\lambda+\mu-\pi-\delta)A_t(e^{(\lambda-\pi-\delta)M_t^{mplt}}-\kappa_t(\lambda-\pi-\delta)-1)}{(\lambda-\pi-\delta)\alpha_t(e^{(\lambda+\mu-\pi-\delta)M_t^{mplt}}-1)}\right]-w_tA_t \qquad (8)$$

The first order condition for a maximum results from differentiation to M_t^{mplt}.

$$\frac{(\lambda-\pi-\delta)e^{(\lambda-\pi-\delta)M_t^{mplt}}\left(e^{(\lambda+\mu-\pi-\delta)M_t^{mplt}}-1\right)-\left(e^{(\lambda-\pi-\delta)M_t^{mplt}}-\kappa_t(\lambda-\pi-\delta)-1\right)(\lambda+\mu-\pi-\delta)e^{(\lambda+\mu-\pi-\delta)M_t^{mplt}}}{(\lambda-\pi-\delta)^2\alpha_t^2\left(e^{(\lambda+\mu-\pi-\delta)M_t^{mplt}}-1\right)^2}=0.$$

Hence, after some operations,

$$\mu e^{(\lambda-\pi-\delta)M_t^{mplt}}+(\lambda-\pi-\delta)e^{-\mu M_t^{mplt}}=\kappa_t(\lambda-\pi-\delta)^2+\mu\kappa_t(\lambda-\pi-\delta)+(\lambda-\pi-\delta)+\mu. \qquad (9)$$

Although the most profitable lifetime M_t^{mplt} cannot be derived analytically from (9), it turns out to be independent of wages and prices[6].

So, by making the capital formation endogenous another, more complete concept of efficiency reveals itself. It points at the stationary economy B in figure 1 as the only one which can be called efficient. Evidently, economy B will also be supported by a neoclassical price-system. Both definitions of efficiency coincide in B. Here we have the "Magna Charta" as Schumpeter calls it (Schumpeter, 1939, p. 69).

At present, models of monopolistic competition in which a representative consumer supplies both labour and capital are fashion setting. In such models profit maximization automatically results in the most efficient production: the consumer will always offer the labour supply which yields the highest consumption. But I would like to suggest taking some distance of these models of monopolistic competition and giving some thoughts to their relevance in understanding reality. Monopolistic competition has to be postulated. In the above model oligopolistic competition quite naturally emerges as soon as it is acknowledged that economies do not always reach their final stage of capital accumulation.

If capital shortages occur for an economy as a whole, there will be firms producing according to point A. But this does not necessarily mean that all firms have to produce according to A, and that they are bound to move in closed ranks as soon as the saving rate allows them to invest more. One or more firms may go ahead and reach a higher level of efficiency which, given the prevailing wages and prices, implies a higher level of profit.

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[6] The second order condition is investigated in appendix B.

In reality we frequently see a wide dispersion of profits amongst firms. This validates the theory suggesting that the majority of firms lies between A and B. Actual production develops between the feasible production of point A and the most efficient production of point B. This latter point, it must be stressed, can only be seen by entrepreneurs. In view of the prevailing wages and prices, defined by the production in point A, economists are not able to determine the most efficient production. Here, the optimality routines of Baumol utterly fail.

In appendix C it is shown that the rate of return on investment of Schumpeterian firms will always be higher than the rate of return of Marshallian firms. The "hidden" higher profit levels and the higher rates of return enable entrepreneurs therefore to enforce the savings they need. Schumpeter rightly stresses the importance of credit and the banking systems in directly serving firms.

So, by taking up the limited savings, the first movers, the entrepreneurs, do not only restrict the potentials of the laggards to follow, but they are also going to get power over them. That is how oligopolistic competition quite naturally comes about.

The thorough analysis of stationary states shows how entrepreneurship may develop in an economy which is characterized by some incremental innovation. A decreasing labour intensity of the production, i.e. $\mu>0$, is needed to generate the most profitable lifetime[7]. This foundation of entrepreneurship asks for a special explanation which goes beyond rational economic action (Schumpeter, 1934, p. 80). The solution of this paradox has to be found in the essence of entrepreneurship: in order to reach a higher profit one has to leave easy profit into the market. While this notion is already difficult to grasp in theory, it explains why in practice differences in firm behaviour may so easily develop. Being an independent factor of production entrepreneurship is unequally spread amongst firms. Moreover, it is not a necessary factor. Therefore, there will always be firms which think to maximize profit by equalizing marginal costs and marginal revenues. And, by lack of entrepreneurship, they are indeed not able to reach a higher profit. Nevertheless, it will sufficiently be clear that such maximization does not

[7] If μ approaches to zero, the economic lifetime becomes infinite and the most profitable lifetime indefinite. The Schumpeterian regime then ceases to exist. So, all firms would necessarily have to stay in the Marshallian regime.

indicate the state towards which an economy is always gravitating (Schumpeter, 1942, p. 79).

We need to distinguish the occurrence of both neoclassical profit maximization and entrepreneurial activity which results in higher profit levels, at the same time. We need to distinguish a Schumpeterian regime which goes along with a Marshallian regime, and have to analyse their interactions and interrelations through the channels of oligopolistic competition.

4. OLIGOPOLISTIC COMPETITION

The dispersion of the *n* firms between A and B of figure 1 could empirically be verified by actual production and employment figures of separate firms vis-à-vis their capital accumulation. By lack of such data, however, it is also possible to analyse, for instance, the manufacturing industry and to assume that the *n* firms could be split up into both Marshallian and Schumpeterian firms. Provided that both the actual production Y_t is generally lower than the sum of the production capacity y_t^* of Marshallian and Schumpeterian firms together and the actual employment A_t is also generally lower than the sum of the profitable labour places a_t^* of both types of firms, the distribution between Marshallian and Schumpeterian firms can be estimated in such a way that the sum of their investments correspond as closely as possible to the actual investments.

To do so, we leave the above model which describes stationary economies. This represents a major change from the original 1996 paper[8]. The current paper does not try to model oligopolistic competition explicitly. Instead we suffice to assume that Schumpeterian firms exist and that they, as a result of oligopolistic competition, are able to produce and sell their commodities at a quite high utilization rate of their production capacity. In that case, by estimating their market share γ_t, we do not only know their

[8] Originally, two stationary economies were distinguished within the same production technology, each with its own initial level of investment and its own growth rate. The only difference was that in the Schumpeterian economy machinery is replaced after the most profitable lifetime and in the Marshallian economy after the economic lifetime. In addition to estimating which distribution between the two economies results in the best possible match with the actual development of production, employment and investment, this paper also tried to arrive at a description of oligopolistic competition, but in fairness it must be said that this did not come out well.

production y_t^{mplt} (with $y_t^{mplt} = \gamma_t Y_t$) but can also estimate their required investments. In addition to the market share of Schumpeterian firms, we also estimate the investment behaviour of Marshallian firms, which allows them to meet the remaining demand for commodities y_t^{eclt} (with $y_t^{eclt} = Y_t - y_t^{mplt}$) and to take into account the activities of the Schumpeterian firms at the same time. With the use of penalties, the estimation process is controlled through iterations in such a way that in one iteration the estimated total investments match the actual investments as closely as possible, while in the other iteration the total production capacity and the available labour places of both types of firms cover the actual production and employment.

More detailed we use a vintage model based on the actual investments and determine the coefficients of the production technology κ, λ, $d\lambda$, α, μ, $d\mu$ and δ that describe both the production capacity, which should generally be enough to provide for the actual production, and the number of profitable labour places that should nicely correspond with the actual employment. As indicated, the estimation procedure consists of two stages, preceded by a preliminary stage. The preliminary estimation determines the coefficients of the feasible production technology of all firms together by assuming that their investments in each year are equal to the actual investments.
The preliminary coefficients found form the input for the first stage of the estimation procedure. By distinguishing Schumpeterian from Marshallian firms the coefficients of the production technology may change. However, at the start of the first stage, the results of the second stage must be anticipated by assuming initial values for which part of the actual production is produced by the Schumpeterian firms year after year. This first stage tries to find coefficients that, given the provided share of the Schumpeterian firms in the actual production, result in a better relation between not only actual production and production capacity but also actual employment and labour places. In the second stage, given the coefficients of the production technology found in the first stage, the share of the Schumpeterian firms in the actual production is actually estimated in such a way that the sum of the investments of Schumpeterian and Marshallian firms is as close as possible to the actual investments. By iteration of both stages an optimal solution will be found.
More precisely, throughout the estimation procedure, the oligopolistic strength of the

Schumpeterian firms becomes apparent from the fact that they determine their own market share and the investments enabling them to produce that market share as efficiently as possible, i.e. with a high utilization rate of their production capacity determined by a replacement of machinery directly after the expiration of the most profitable lifetime. The Marshallian firms react defensively with investments mainly determined by the development of their market share and capacity utilization.

More explicitly, in the second stage for each year a coefficient γ_t is estimated that indicates what proportion of the actual production in that year is provided by Schumpeterian firms and what investment $i_t^{mplt\text{-}stat}$ is needed to produce that production year after year as if they were in a stationary economy.
At the same time as γ_t, an adjustment coefficient ξ_t is determined with $0 \leq \xi_t \leq 1$.
To explain their mutual relationship two cases can be distinguished:

- $\gamma_t > \gamma_{t-1}$

In case of an increasing γ_t then $\xi_t=1$ means that Marshallian firms start to produce like Schumpeterian firms, for example, because a Schumpeterian firm takes over a Marshallian firm with its old machines that do not remain in use for longer than the most profitable lifetime. However if $\xi_t=0$ then Schumpeterian firms are expanding their production with only new investments. Their past investments remain unchanged. In advance of a further rising market share the new investment may be higher than what is needed for a stationary state. Therefore we introduce a coefficient ζ as you will see in a moment.

- $\gamma_t < \gamma_{t-1}$

In case of a decreasing γ_t, then $\xi_t=1$ means that Schumpeterian firms become Marshallian firms by using their existing machinery longer. If $\xi_t=0$ the Schumpeterian firms just reduce their new investments but continue to put out of use their older machinery after the most profitable lifespan.
The actual new investment of Schumpeterian firm i_t^{mplt} follows from

$$i_t^{mplt} = (1 + (1 - \xi_t) * \zeta) * i_t^{mplt-stat}.$$

This equation implies that ζ ($0<\zeta<1$) has only influence if $\xi_t<1$, which means that Schumpeterian firms in case of an increasing γ_t expand their production with relatively more new investments. These additional investments would allow Schumpeterian firms to consolidate and strengthen their market share expansion. In case ξ_t=1 their actual investment i_t^{mplt} will equal $i_t^{mplt\text{-}stat}$.

In addition to these coefficients we also estimate a coefficient β. By their relatively high profits Schumpeterian firms may also use their oligopolistic power to set their wages β per cent higher than Marshallian wages. So,

$$w_t^{mplt} = (1+\beta)w_t^{eclt}.$$

Given the actual wages w_t, the actual employment A_t and the number of profitable jobs $a_t^* = a_t^{*mplt} + a_t^{*eclt}$ holds by definition

$$w^t = \frac{w_t^{mplt}\frac{a_t^{*mplt}}{a_t^*}A_t + w_t^{eclt}\frac{a_t^{*eclt}}{a_t^*}A_t}{A_t},$$

which enables to compute the wages of both Schumpeterian and Marshallian firms.

The investment equation of Marshallian firms with three coefficients ρ is given by

$$i_t^{eclt} = \rho_1(y_t^{eclt} + y_{t-1}^{eclt} + y_{t-2}^{eclt})/3$$
$$+ \rho_2 qy_t^{eclt}(y_t^{eclt} + y_{t-1}^{eclt})/2 + \rho_3 qy_t^{eclt}(i_t^{mplt} - i_{t-1}^{mplt}) + \kappa_t y_{t-eclt}^*$$

where qy_t^{eclt} shows the utilization rate of the production capacity of the Marshallian firms in year t and $\kappa_t y_{t-eclt}^*$ the replacement investments in that year. It turns out that the investments of Marshallian firms also responds to Schumpeterian firms' investments.

As already noted, after the second stage estimation, we investigate whether the coefficients determining the production technology can be improved on the basis of the estimated distribution of Marshallian and Schumpeterian firms. After improved estimation results for the production technology of both type of firms, the coefficients of the second stage may also lead to improvement. This creates an iterative process that stops as soon as improvement is no longer possible.

Both stages of the estimation procedure are iteratively performed with the Fortran routine E04UCF of the Numerical Algorithm Group which minimizes a function subjected to linear and nonlinear constraints. The iterations serve to fix the unobserved

variables that, while resulting from one stage, constitute the input of the other stage of the estimation procedure.
The objective functions search for the best fit between both actual production and production capacity and actual employment and profitable labour places, together with a search for the least squares of the differences between the actual and estimated development of aggregate investment, whilst assuring an high utilization rate of Schumpeterian firms. The relative presence of entrepreneurship appears from the chain of coefficients γ_t. Together with the chain of coefficients ξ_t it expresses how entrepreneurship has developed over time, or, more accurately, might have been developed over time in order to provide for a framework in which Schumpeterian and Marshallian firms interact in such a way that actual production, employment and investment could adequately be explained. The estimated chains of coefficients γ_t and ξ_t ultimately only serve to make the contribution of Schumpeterian and Marshallian firms to the actual development of production and employment plausible.
Explaining the behaviour of entrepreneurs itself, as it appears from the changes in γ_t and ξ_t, is another topic. It calls for a detailed description of the oligopolistic behaviour of Schumpeterian firms that determines the magnitude of their investment, production and employment combined with their influence on wages and prices that determine the behaviour of Marshallian firms. This description lies beyond the scope of this study.

5. EMPERICAL RESULTS

Before entering into the empirical results we first investigate whether the facts of the manufacturing industry in the United States, Germany, France and the United Kingdom reveal the relevance of the tendency towards more efficient production as shown by the Solow growth model in figure 1.
Figure 2 shows the development of the surplus product in combination with the shares of wages and investments in the total added value of the manufacturing industry in the four countries separately. It appears that US manufacturing, in line with figure 1, has tended towards more efficient production during the 1960s and 1970s. But from the 1980s onward the surplus product only seems to be growing.

Figure 2

Decomposition of gross value-added manufacturing industry (current factor cost): share of investments, surplus product and wage share, excluding (dotted line) and including imputed wages (solid line)

Source: OECD International Sectoral Data Base (ISDB), 1995 and STAN Database for Structural Analysis, 2020.

In Germany, the fall in the surplus product seems to have continued even into the early 1990s. Subsequently, the surplus product also increased here, with a striking outlier during the financial crisis in 2009. The pictures for France and the United Kingdom, however, show hardly any trend development.

A second set of facts, shown in figure 3, concerns employment and the volume of production and investment. The strong fall in employment in US manufacturing since the beginning of the present century is striking. In the United Kingdom, the relatively much stronger decline started earlier. To a lesser extent, this also applies to France. Germany shows the most limited decline. It is also striking that, despite the fall in employment, the production volume in the US has risen much faster since 1991 than in Germany and France, with Germany almost catching up with France. In the UK, the sharp drop in employment goes hand in hand with a barely increasing production volume.

In order to better see these developments in coherence, the production volume per worker, as measured by the volume of gross value added per worker, is split into net value added per worker and investments per worker.

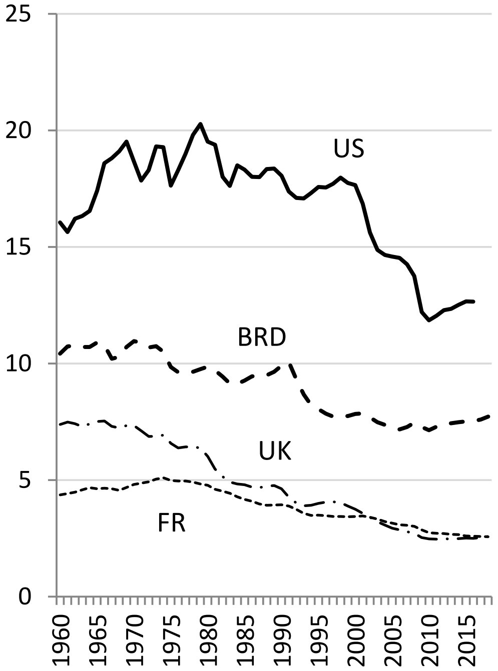
Investment per worker in the US is rising (in figure 3 up to more than 500 in 2016) faster than net output per worker (below 400 in 2016). The reverse is true in France, while both are increasing at the same rate in Germany. But here it is striking that the investment per worker in the UK increases the most, while its net output per worker is slightly higher than in Germany.

These differences in facts are also reflected in the estimation results. By distinguishing two estimation periods, namely 1960-1993 and 1975-2018, we may gain insight into possible structural changes in the manufacturing industry, whether or not induced by the 1973 oil crisis. These can be deduced, for example, from shifts in the patterns of the most profitable and economic lifetime of machinery. In this respect, tables 4 to 7 allude to the largest structural changes in the US and the smallest in Germany.

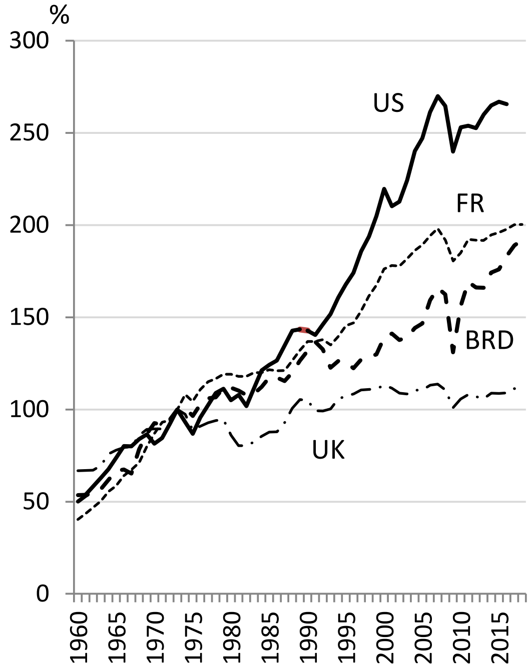
Table 4 with the US results shows a strong increase in the estimated share of Schumpeterian firms in the actual production, starting in 2000, with a corresponding increase in their investments.

Figure 3
Manufacturing industry: actual volume of production, employment and investment in the four discerned countries

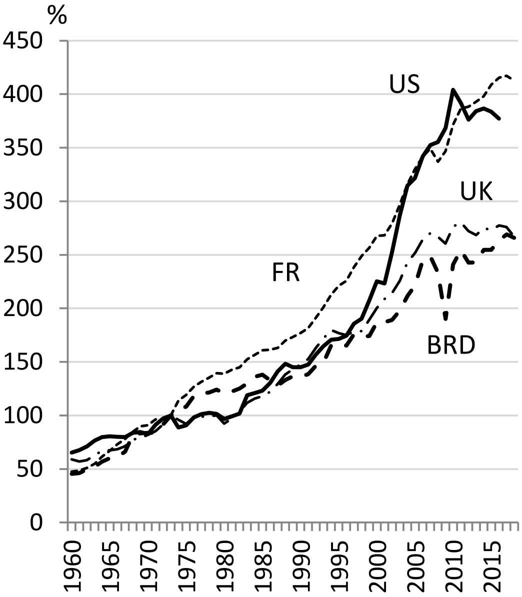
Employment (millions)



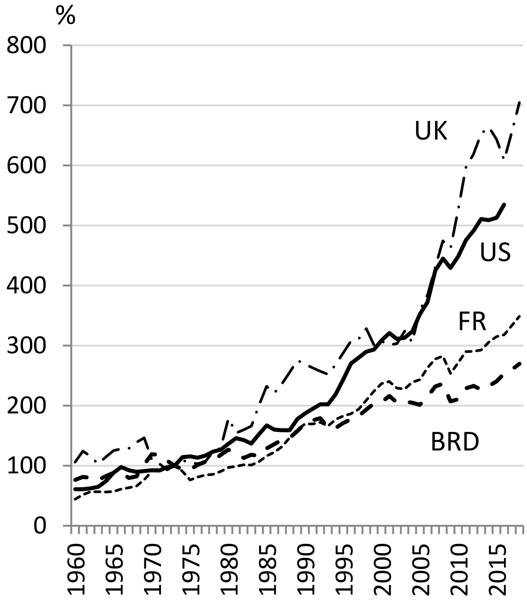
Gross value added (1973=100)



Net value added per worker (1973=100)



Investment per worker (1973=100)



Source: OECD International Sectoral Data Base (ISDB), 1995 and STAN Database for Structural Analysis, 2020.

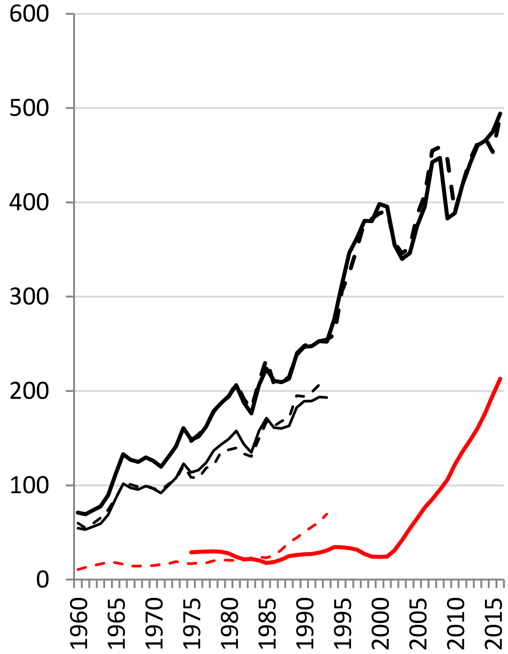
The strong capital intensification of production already shown by the rising investment share in figure 2 is also reflected in the steady increase in the most profitable lifetime of machinery. That capital intensification has increased in the estimation period 1975-2018 is evidenced not only by the higher level of the most profitable lifetime relative to the 1960-1993 estimates, but also by their higher rates of increase. Moreover, it is also illustrative that the capital output ratio κ increased from 1.51 in 1993 to 3.87 in 2016, as shown in table 1 below. Compared to investments, the share of the Schumpeterian firms in total employment remains relatively limited: the strong increase in economic lifetime enables Marshallian firms in the US to keep their machinery in use for longer.

The development of market share and investments of Schumpeterian firms in Germany is comparable to that in the US. This applies not only to the estimation period 1960-1993, but also and especially to 1975-2018. Here too there has been a strong increase, although it already started around 1975, which then faltered over a period of about fifteen years before showing a sharp increase again after 2005.
In contrast to the US, the most profitable lifetime in Germany continues to develop more in line with the estimated development in 1960-1993. This reflects not only less structural changes in comparison with the US but also the fact that in Germany net output and investment per worker both increase more or less similarly over time.

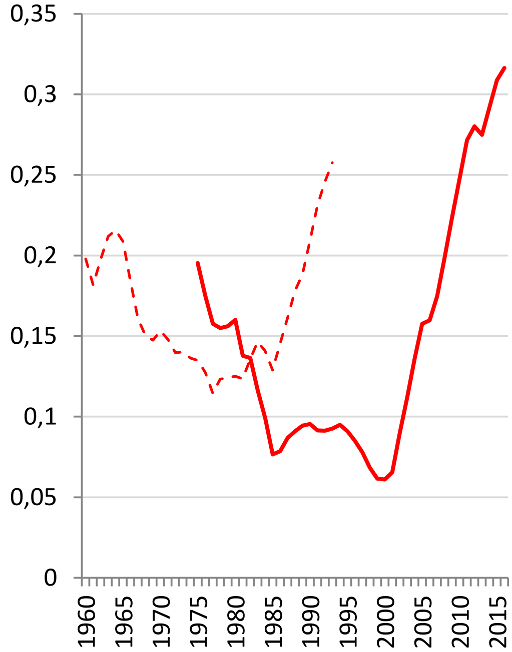
As in the US, the share of investments in total added value has also increased to a relatively high level in France, as shown in figure 2. This apparent capital intensification is also reflected in the capital output ratio, which has increased in France from 2.27 in 1993 to 3.88 in 2018 as shown in table 1. The high level of investments seems to reflect the strong rise of the estimated market share and investments of Schumpeterian firms in France after 1980. This rise that undoubtedly contributed to the rise of the net production per worker, came to an end in 2002. While the market share of Schumpeterian firms dropped substantially, their investments started however to recover from 2012.
The development of the most profitable lifetime in the period 1975-2018 is at a clearly higher level than in 1960-1993, although the rate of increase has decreased. After the US, these are the clearest indications of structural changes in France.

Figure 4
United States: estimation results manufacturing industry

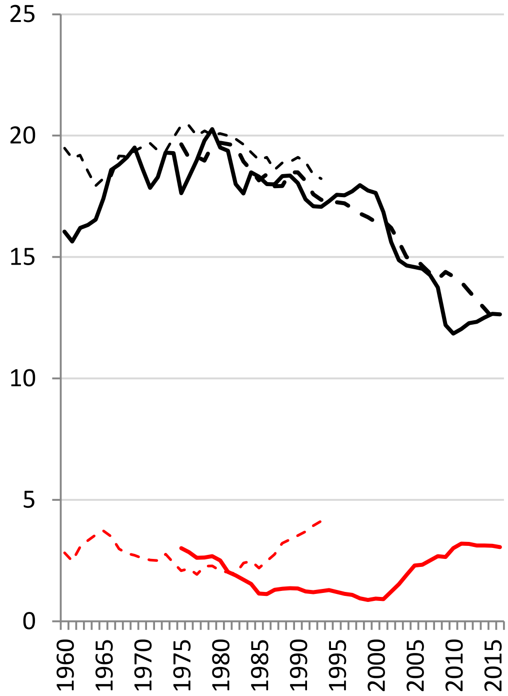
Actual and estimated investment
(in red: investment Schumpeterian firms)



Estimated share of Schumpeterian firms
in actual production



Employment and labour places (millions)
(in red: employment Schumpeterian firms)



Most profitable and economic lifetime
(dotted lines reflect stationary economy)

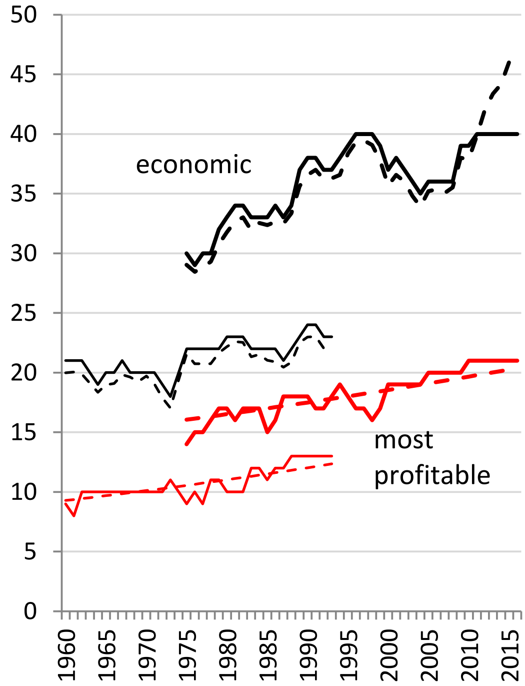


Figure 5
Germany: estimation results manufacturing industry

Actual and estimated investment
(in red: investment Schumpeterian firms)

Estimated share of Schumpeterian firms
in actual production

Employment and labour places (millions)
(in red: employment Schumpeterian firms)

Most profitable and economic lifetime
(dotted lines reflect stationary economy)

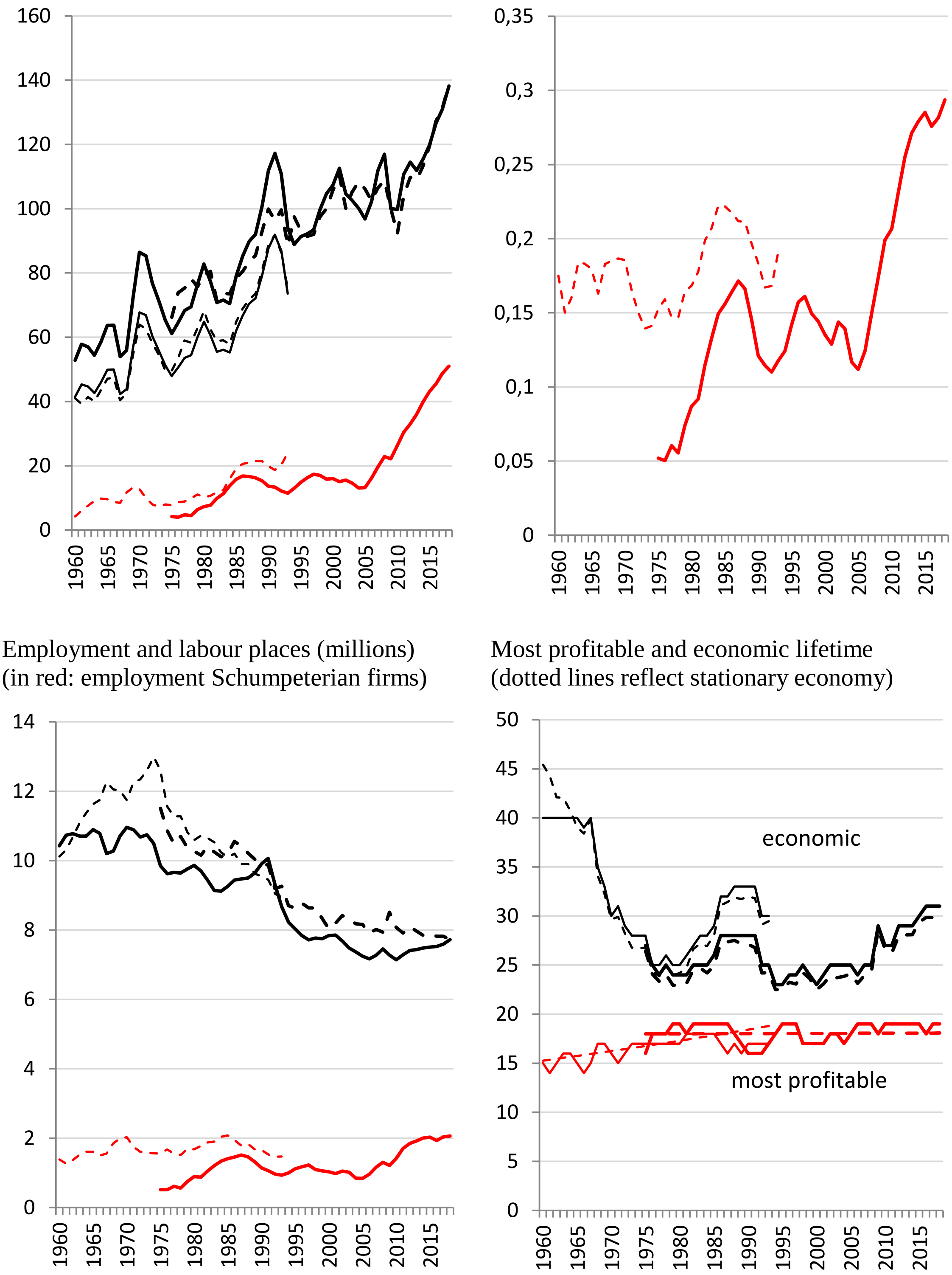
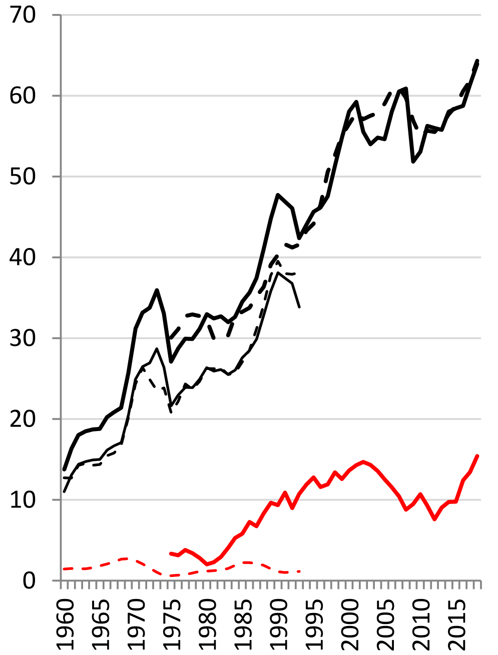
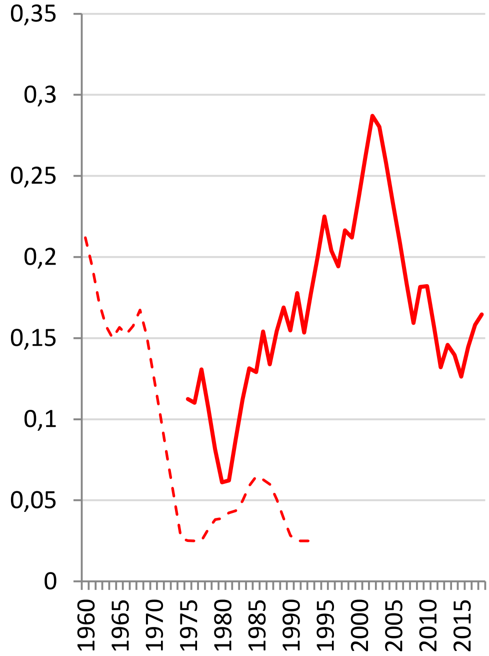


Figure 6
France: estimation results manufacturing industry

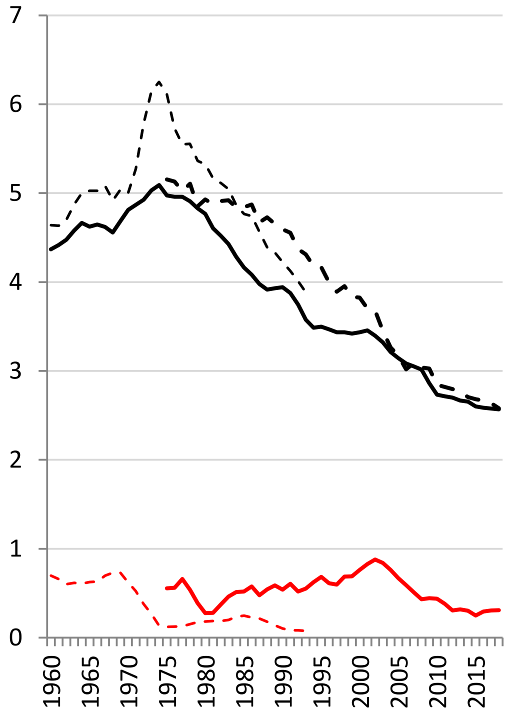
Actual and estimated investment
(in red: investment Schumpeterian firms)



Estimated share of Schumpeterian firms
in actual production



Employment and labour places (millions)
(in red: employment Schumpeterian firms)



Most profitable and economic lifetime
(dotted lines reflect stationary economy)

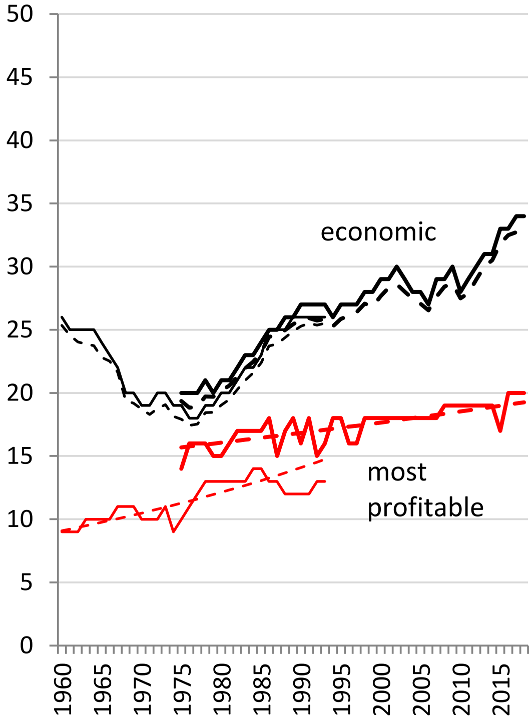
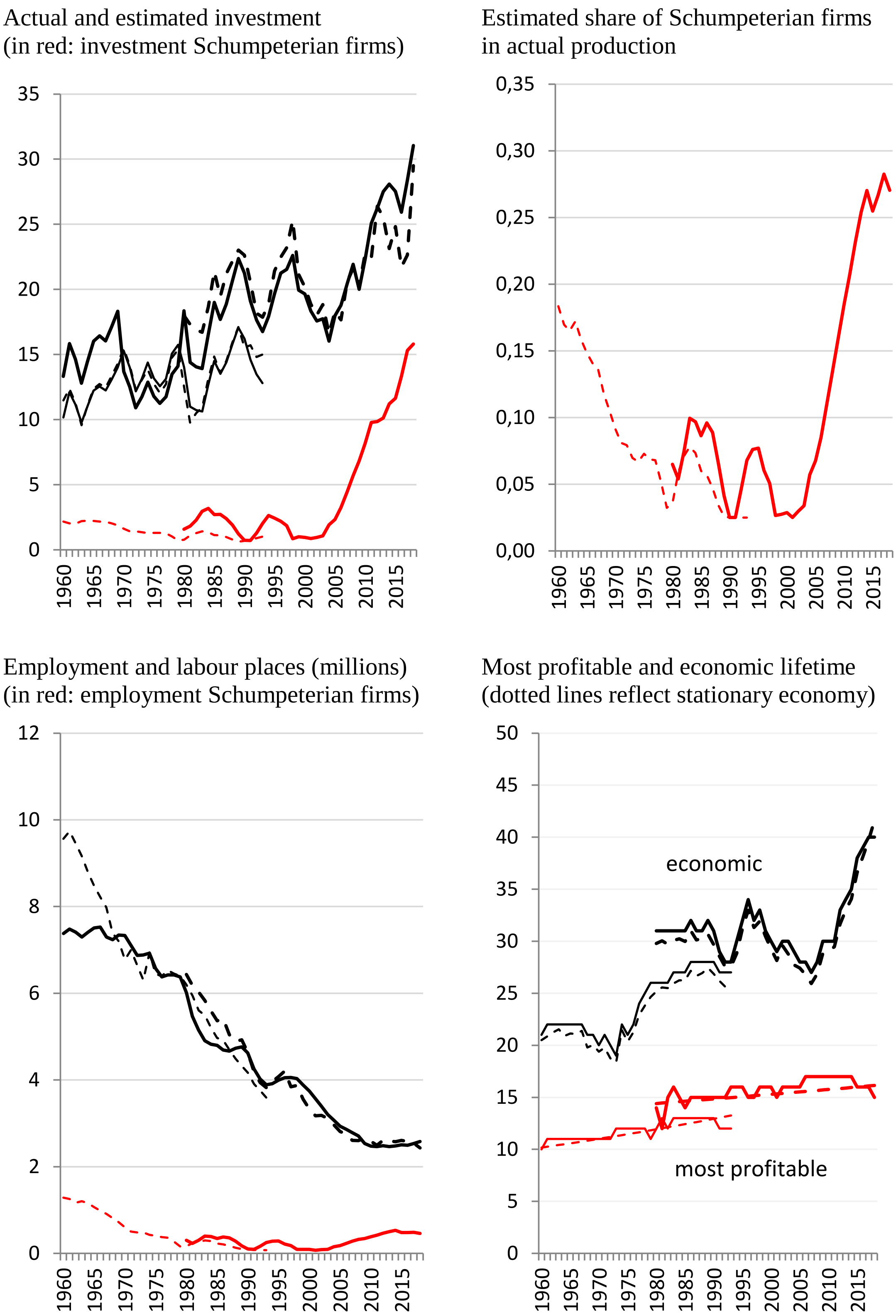


Figure 7
Unites Kingdom: estimation results manufacturing industry



As stated before, the development of the estimated market share and investments of Schumpeterian firms in the United Kingdom largely corresponds to that of the US manufacturing industry. However, it should be noted that the second estimation period has been shortened to 1980-2018. The increase in investments in response to accession to the European Union in 1973 prevented a successful outcome of an earlier estimation procedure.

In conclusion it should be stressed that the estimated development of investments is frequently close to its actual development, and that this could only be achieved through the supposed market share and investment behaviour of Schumpeterian firms. As a result of this approach, it seems clear that Schumpeterian firms in the US, Germany and the UK have seen their market share increase significantly since the year 2000. However, a question remains whether and to what extent their increasing competitiveness has come at the expense of the manufacturing industry in France.

Table 1
Estimation results, feasible production in 1960-1993[9] and 1975-2018[10]

Coefficients production technology	US		Germany		France		UK	
	1993	2016	1993	2018	1993	2018	1993	2018
α	12.64	3.77	17.33	8.5123	15.14	6.29	21.86	7.44
μ	0.0291	0.0245	0.0207	0.0239	0.0297	0.0304	0.0325	0.0241
$d\mu$	-0.0003	0.0141	0.0088	-0.0004	0.0109	0.0085	0.0076	0.0100
κ	1.51	3.87	2.49	2.79	2.27	3.88	2.16	2.57
λ	-0.0076	0.0191	0.0013	-0.0073	-0.0134	-0.0222	-0.0142	0.0233
$d\lambda$	0.0223	-0.0086	0.0092	0.0075	0.0395	0.0309	0.0288	-0.0175
δ	0.0608	0.0355	0.0440	0.0259	0.0301	0.0071	0.0178	0.0375
ν	-0.0121		-0.0573		-0.0750		-0.0259	
eclt regime								
β	0.0468	0.0	0.0395	0.0	0.0	0.0	0.0301	0.0
ρ_1	0.0904	0.0520	0.0030	0.0122	0.0194	0.0329	0.0002	0.0260
ρ_2	0.0378	0.0142	0.0718	0.0417	0.0744	0.0309	0.0627	0.0009
ρ_3	-4.8188	-10.0	-2.6324	-4.1801	-10.0	-0.3415	-10.0	-4.5845
ς	0.4094	0.4443	0.9307	0.2835	0.3422	0.6946	1.0	0.7582

All in all, the estimation results may demonstrate that the distinction between Schumpeterian and Marshallian firms is quite able to explain the development of actual investment, while the estimated production capacity and profitable labour places nicely

[9] Up to 1973 a disembodied capital saving development ν is estimated, only for the Marshallian regime. It indicates the increasing advantages of economies of scale, especially in the European countries.
[10] For UK 1980-2018.

correspond with actual production and employment.
However, the purpose of these estimations is rather limited. They mainly serve to show the applicability of the theory. We should therefore be careful in drawing conclusions from such a rough model, which, for instance, does not reflect divergent developments within the manufacturing industry. Neither it reflects the international competition by which the prices could also be based upon the marginal costs of other countries.[11] The model evokes further investigation, especially regarding the chains of estimated coefficients γ_t and ξ_t which strongly contribute to the explanation of investment and employment, without to be explained themselves. In order to add forecast capabilities to the model, these chains of coefficients have also to be explained. Properly speaking, this asks for an explanation of entrepreneurial behaviour.

6. ECONOMIC DEVELOPMENT

Studies as Klepper and Simons (1994) show that from an initial situation of perfect competition many manufacturing industries, such as automobiles and televisions, have gradually been evolved into tight oligopolies. In other industries, for instance detergents, small producers still exist on markets which at present are dominated by a few worldwide operating firms.
Klepper and Simons examine the relation between industry shakeouts and technological change. Based on the regularities they found (older and larger firms had higher survival rates and the earliest entrants tended to survive longest) they stress the importance of process innovation as a critical determinant of success. Klepper (1996) shows the importance of the size of the firm. Firms differences appear to be at the root of important phenomena of the product life cycle.
In addition to these findings I would like to stress the importance of entrepreneurship. As soon as there is some process innovation, as indicated by $\mu > 0$ which implies a decreasing labour intensity of the production, there is also room for entrepreneurship to

[11] This could turn out from an investigation of different manufacturing sectors, such as machinery or transport equipment, within and across countries. This can also include the export of their commodities and the extent to which their production is influenced by the import of competing commodities.

discover higher levels of efficiency. More efficient production subsequently allows expansion of entrepreneurial firms at the expense of other firms. It also provides for a buffer to survive in hard times, and to develop new products and production processes or to buy up small promising firms in good times.

Chandler's impressive *Scale and Scope* rightly stresses the importance of organizational capabilities and economies of scale. The observed strengthened oligopolistic competition seems founded on higher levels of efficiency. In describing economic reality Chandler also clarifies why entrepreneurs do not buy out all competition and benefit from the occurrence of less efficient firms (Chandler, 1990, p. 76). From the evidence one cannot but conclude: it is oligopolistic competition that drives economic development.

Focused on the organizational capabilities Chandler seems to restrict entrepreneurship to innovative activity. His "first movers" frequently show capabilities which make organizations able and willing to adapt to change. This paper advocates a broader concept of entrepreneurship, although it is similarly confined to the first movers in an economy without changes in the coefficients which determine the feasible production set. In reality the production technology is continuously changing. Apart from incremental innovation there is radical product and process innovation as well. Allowing for changes in the parameters is a next step towards a more complete description of entrepreneurship and the different ways in which innovation trickles towards the Marshallian regime.

To indicate another important route towards a better understanding of economic development, a reference has to be made to Schumpeter's *Capitalism, Socialism and Democracy* which points at the similarity between entrepreneurship and political leadership. Striking into new roads towards higher levels of welfare or making a dent in persistent unemployment may ask for societies which are equally able and willing to adapt to change as the organizations of entrepreneurs.

As the neoclassical theory turns out to get stuck in sub-optimality analysis and fails to discover more efficient, i.e. more profitable, production, it equally fails to provide an adequate framework for policy analysis. At the level of a society the neoclassical theory is bound to interpret persistent unemployment as a consequence of bad functioning markets. More than once this has given rise to rather drastic policy advices to dismantle the organizational capabilities of the society, i.e. the institutions and regulations which were both cause and consequence of earlier economic growth.

Economic reality could be far more complicated. The assessment how Schumpeterian and Marshallian firms react on each other, is not easy to make. In a climate of uncertainty contractive tendencies could readily emerge. Moreover, the road towards higher levels of welfare could be blocked by temporary unemployment. Resistance to change could therefore preserve a stagnating economic development.[12]

So, a more comprehensive analysis is needed, for instance along the lines indicated by Baily et al. (1993). By reckoning with the various interactions between the search for profit by using and developing the production technology at the micro level and the search for a productive balance between social security and economic dynamism at the macro level, economic development ultimately appears to be an evolutionary process (see also Nelson and Winter (1982)).

7. CONCLUSIONS

1. Profit maximization by equalizing marginal costs and marginal revenues only results in efficient production by accident. This first conclusion refers to a concept of efficiency which goes beyond the rational economic action as described by the neoclassical theory. However, the neoclassical theory remains of importance in explaining economic development. It adequately describes a part of the reality, the Marshallian regime. Here, firm behaviour is fully in accordance with the neoclassical theory. But the existence of a Schumpeterian regime has also to be acknowledged.

2. The higher levels of efficiency, attained by Schumpeterian firms, give rise to oligopolistic competition which involves both price setting behaviour and wage formation. It is oligopolistic competition, which so evidently links up with reality, that

[12] In his message to the EC Employment Week of October 1993 the US secretary of Labour, Robert Reich, got to the heart of the matter: "Unless people have the security they need to adapt to the future, I believe they will seek security by trying to preserve the past. These two are the only practical choices in a free society, but the latter choice, trying to preserve the past, leads ultimately to stagnation." The OECD Jobs Study uses similar words and points at the decrease in "the economy's ability, and sometimes also society's will, to adapt" (OECD (1994), p. 29). See also Moons (1994) for a more comprehensive analysis of persistent unemployment.

drives economic development.

3. A simple model of oligopolistic competition already suffices to provide for a rather good explanation of differences in economic development. Assuming a production technology which is basically the same for the manufacturing industry of the United States, Germany, France and the United Kingdom, differences in development could easily be explained, without the necessity of introducing changes in the production technology which could not instantly be followed by other producers.

4. Therefore, entrepreneurship in a stage without technological shocks seems rather important. This conclusion links up with case studies focusing on the importance of economies of scale and process innovation. It is also in line with Chandler's analysis of first mover advantages and oligopolistic competition (Chandler, 1990).

5. Modelling oligopolistic competition does not only reflect reality, it also offers opportunities to integrate both the neoclassical and the evolutionary approaches of economic change. The neoclassical theory describes the Marshallian regime. The other theory, as developed by Nelson and Winter (1982), is of importance because the interaction between both the Schumpeterian and the Marshallian regime results in developments which are evolutionary by theirs vary nature.

6. Moreover, the presented theory provides for a better understanding of persistent unemployment. Contraction of economic activity towards the Schumpeterian regime may result in hardly to solve shortages of employment opportunities, especially in times of technological change.

Appendix A: Steady states and the Golden Rule of Accumulation

According to the Solow growth model the production per worker *y* increases with the capital stock per worker *k*, as shown by $y=f(k)$ in figure A1. Given the saving rate *s*, which divides *y* into investment and consumption, and the depreciation rate δ this figure illustrates the tendency towards the steady state k^*_1. Below k^*_1 investment exceeds depreciation, so *k* will grow. Above k^*_1 the capital stock will shrink because investment is less than depreciation. The figure also illustrates that a higher saving rate will evoke a new steady state k^*_2.

By comparing steady states one might ask which steady state yields the highest level of consumption per worker. Figure A2 visualizes the way in which Phelps (1961) has derived the Golden Rule of Accumulation. For any saving rate he determines the steady state output $y^*=f(k^*)$. The steady state which maximizes consumption results by looking for the greatest difference between $y^*=f(k^*)$ and the investment as denoted by the depreciation rate.

A similar figure could be derived from the vintage model as presented above. In figure 1, presented in section 2 of this paper, the steady states are classified after the economic lifetime. By relating this lifetime to the capital stock per worker, this figure 1 could be mirrored into a figure of the production and investment per worker in relation to the capital stock. Figure A3 shows that the optimal consumption according to the Golden Rule of Accumulation occurs as soon as the production is in accordance with the most profitable lifetime.

One striking difference with figure A2 concerns investment. In the Solow growth model the investment per worker equals the depreciation δ of the exogenous capital stock per worker. In the vintage model of figure A3 the capital stock endogenously depends on the total available labour. This results in a rapid rise in investment as soon as the lifetime of machinery approaches to zero. The required investment may even exceed production if the capital output ratio is higher than one.

Furthermore, it should be acknowledged that in the Solow growth model the steady state investment does not only depend on the depreciation rate, but also on the economic lifetime of machinery as determined by the wages and prices which support the steady state. Although the adjustment processes towards the steady state k^*, as shown by figure A1, only concern the investment activity, they could more thoroughly be described by discerning wages and prices and the savings from labour and capital income.

However, market forces do not generate similar neoclassical adjustment processes towards the Golden Rule level k^{**} of figure A2. For such a process one frequently defines a policy objective for the economy as a whole which also implies a comparison of welfare over time. A temporary drop in consumption and a corresponding jump in investment may be necessary to reach the Golden Rule level from below k^{**}. Concern about the consumption of the current generations may therefore conflict with policies to attain the Golden Rule steady state.

The vintage model, however, makes clear that the Golden Rule of Accumulation may be reached by other mechanisms. Its coefficients, that describe the production technology, imply the existence of a most profitable lifetime. Entrepreneurial firms, which produce according to this lifetime, might therefore pave the way to the Golden Rule of Accumulation, while policies explicitly targeted on the optimal saving rate could turn out difficult to settle.

Phelps' Oiko was quite able to advise a saving and investment rate equal to the capital income share. But he failed to prescribe the daily practice of firms replacing their machines after their most profitable lifetime.

Figure A1
Solow growth model

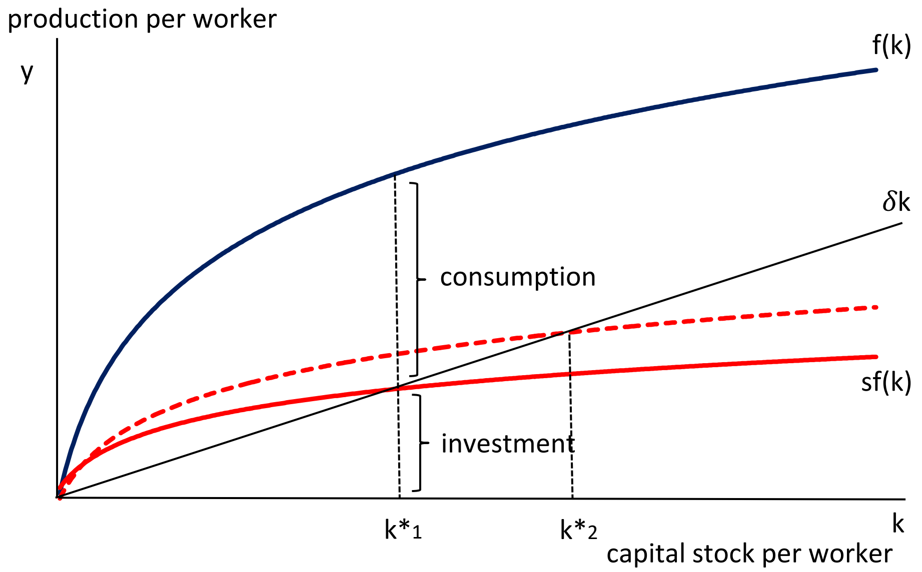


Figure A2
Golden Rule of Accumulation

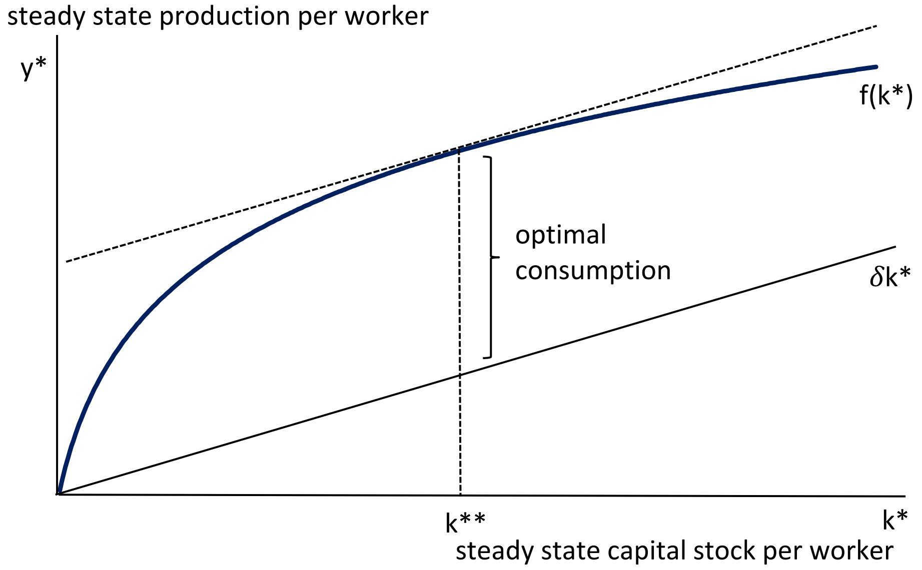
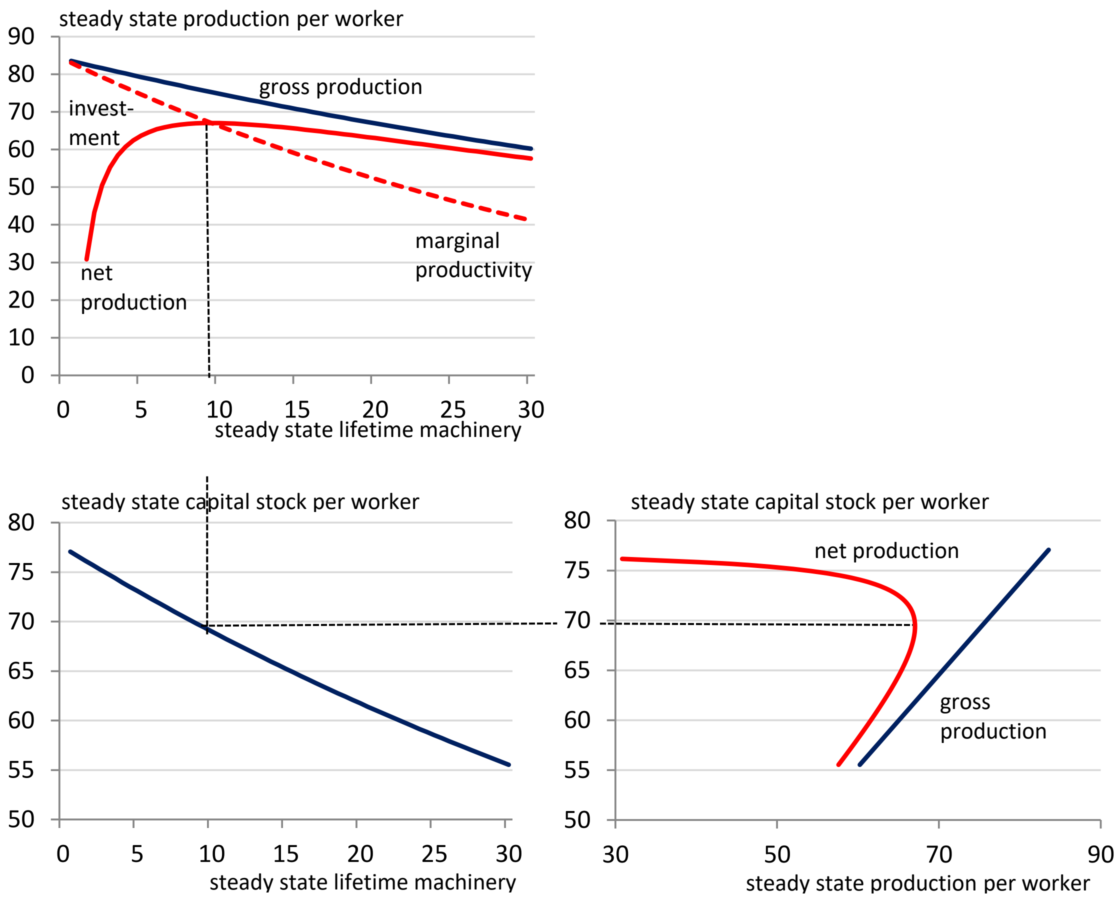


Figure A3
Golden Rule of Accumulation following from the vintage model



These figures reflect the estimated production technology of the US manufacturing industry in 1997 (current prices, $ thousand)

Appendix B: Investigation second order condition

In maximizing (8) the second order condition

$$\frac{\delta^2 p}{dm^2} = \frac{\left(-2\mu - \frac{\mu^2}{(\lambda-\pi-\delta)}\right)e^{(\lambda-\pi-\delta)M} - (\lambda-\pi-\delta)e^{-\mu M} + (\lambda+\mu-\pi-\delta)(\kappa_t(\lambda+\mu-\pi-\delta) + 1 + \frac{\mu}{(\lambda-\pi-\delta)})}{e^{(\pi+\delta-\lambda-\mu)M}}$$

is fulfilled if the numerator is negative. This is assured if

$$\pi + \delta > \lambda + \mu \qquad (16)$$

To investigate this inequality we rewrite the investment equation (7) complying with full employment in first differences. So,

$$i_{t,t}^{mplt} = \frac{\kappa_t(\lambda+\mu-\pi-\delta)A_t}{\alpha_t(e^{(\lambda+\mu-\pi-\delta)M_t^{mplt}} - 1)}$$

results in

$$\frac{di_{t,t}}{i_{t,t}} = \frac{dA_t}{A_t} + \frac{d\kappa_t}{\kappa_t} + \frac{d(\frac{1}{\alpha_t})}{(\frac{1}{\alpha_t})} + \left(e^{(\lambda+\mu-\pi-\delta)M} - 1\right)d\left(\frac{1}{e^{(\lambda+\mu-\pi-\delta)M} - 1}\right)$$

$$= \frac{dA_t}{A_t} + \frac{d\kappa_t}{\kappa_t} + \frac{d(\frac{1}{\alpha_t})}{(\frac{1}{\alpha_t})} + (e^{(\lambda+\mu-\pi-\delta)M} - 1)\frac{(\lambda+\mu-\pi-\delta)e^{(\lambda+\mu-\pi-\delta)M}}{(e^{(\lambda+\mu-\pi-\delta)M}-1)^2}dM$$

Hence

$$\pi = \rho + \lambda + \mu + \frac{(\lambda+\mu-\pi-\delta)e^{(\lambda+\mu\pi-\delta)M}}{e^{((\lambda+\mu\pi-\delta)M} - 1}dM$$

Therefore, in stationary states (16) holds if

$$\rho + \delta > 0.$$

So, even in the case of a negative growth of the labour supply, it is unlikely that δ will be so low that the sum of both will be zero or negative at the same time.

Appendix C:Rate of return on investment

From appendix B it follows that if two stationary economies have the same feasible production technology and the same labour supply, they will also have the same rate of investment growth π, irrespective of differences in the actual lifetime of machinery.
Suppose that in one stationary economy the production is in accordance with the most profitable lifetime, while the wages and prices are the same as in the other stationary economy in which machinery is held in operation as long as the economic lifetime has not yet been passed.
In order to prove that the rate of return on investment of the Schumpeterian stationary economy r_t^{mplt},

$$r_t^{mplt} = \frac{1}{\kappa_k} - \frac{(\lambda-\pi-\delta)(\kappa_t(\lambda+\mu-\pi-\delta)+e^{-\mu M_t^{eclt}}(e^{(\lambda-\pi-\delta)M_t^{mplt}}-1))}{\kappa_t(\lambda+\mu-\pi-\delta)(e^{(\lambda-\pi-\delta)M_t^{mplt}}-1)},$$

will always be higher than the Marshallian rate of return r_t^{eclt},

$$r_t^{eclt} = \frac{1}{\kappa_k} - \frac{(\lambda-\pi-\delta)(\kappa_t(\lambda+\mu-\pi-\delta)+e^{(\lambda-\pi-\delta)M_t^{eclt}}-e^{-\mu M_t^{eclt}})}{\kappa_t(\lambda+\mu-\pi-\delta)(e^{(\lambda-\pi-\delta)M_t^{eclt}}-1)},$$

we may look at the difference r_t^{mplt}- $r_t^{eclt,}$,

$$r_t^{mplt} - r_t^{eclt} = \frac{(\lambda-\pi-\delta)}{\kappa_t(\lambda+\mu-\pi-\delta)e^{\mu M_t^{eclt}}}\Pi, \qquad (17)$$

and prove that this difference will always be positive. After some reformulation we find

$$\Pi = \frac{\left(e^{(\lambda+\mu-\pi-\delta)M_t^{eclt}}-1\right)+\kappa_t(\lambda+\mu-\pi-\delta)e^{\mu M_t^{eclt}}}{e^{(\lambda-\pi-\delta)M_t^{eclt}}-1} - \frac{(e^{(\lambda+\mu-\pi-\delta)M_t^{mplt}}-1)+\kappa_t(\lambda+\mu-\pi-\delta)e^{\mu M_t^{eclt}}}{e^{(\lambda-\pi-\delta)M_t^{mplt}}-1}$$

Evidently, the prefix of equation (17) will always be positive. The first term of Π will always be greater than the second one as long as the economic lifetime exceeds the most profitable lifetime. QED.

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