GRAZSCHUMPETERCENTRE

GSC Discussion Paper Series

Paper No. 15

Schumpeterian Adaption and Labour Shortage: Reconsidering Investment

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Abstract

This paper discusses the importance of assumptions in respect to the analytical framework of a one-sector model when it is used to explore an economy's adaption path due to innovation. The focus thereby lies on investment - its determination and dependence on other variables. The chosen approach by means of agent-based modelling allows for simulations of exemplary settings and thereby for illustrative analysis. The paper mainly points out that more detailed investigations also need for a more comprehensive analysis and a system approach.

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1 Introduction

Albert Einstein suggested to „make things as simple as possible - but not simpler". Examining economic models one may assert that our discipline heeded especially the first part of Einstein's advice. For a good reason one of the most famous quotes of Joan Robinson (1962, p. 33) is „that a model which took account of all the variegation of reality would be of no more use than a map at the scale of one to one". This unchallengeable truth, however, did not intend to rubber-stamp every simplification coming to economists minds. Instead Robinson and Eatwell (1973, p. 54) themselves taught that simplifying assumptions have to be selected „without eliminating the features necessary for safe guidance" and especially „the nature of the social system" of interest.

As it seems quite hard to capture the complex nature of capitalist market economies within the mathematical frameworks applied by classical and neoclassical approaches, it is time for some innovation and imitation within the economic science. This is not a request for denying all the progression made within the last century. It rather is an invitation to close the well done matter at this level of abstraction and go one step further towards reality. That one can gain valuable insights also within strongly simplified framework is shown by David Haas (2015). The paper in hand first illustrates this benchmark and its appreciated implications as sort of completion of the task. Secondly, though, it argues that further analysis and more generally valid conclusions have to be based on more comprehensive approaches.

2 Application of the benchmark

Assume an economy that produces just one good by homogeneous labour and capital. Both input factors are combined in a Leontief production function applied by two identical firms aiming at full utilization of their capital stock. Labour is provided by workers consuming all their income. As the produced good is the single and universal one, consumption is a residual of the output not invested in capital stock, but delivered to the always clearing market. Now assume the emergence of a new profitable technology available to only one of the two firms competing for workers out of a constantly growing population by a small differential in their fixed wage rates. Wage rates fixed imply that labour serves as numeraire and the price of the consumption good can be read in terms of labour commanded.

Haas (2015) applies this bundle of assumptions and a corresponding analytical model to explore an economy's adaption paths depending on different types of process innovation. The chosen typology focuses on the relative change of factor input coefficients due to innovation and therefore underlines the relevance of the factor bias a technical change might imply. A positive bias on labour (ϕ_l) or capital (ϕ_k) implies that the new production method uses the corresponding input factor more intensively. Based on the chosen typology of process innovation and factor bias causal effects on the growth rate of output (g_x) and employment (g_L) within the innovation period are captured (see tab. 1, acc. Haas, 2015, p. 14, tab. 1).

However, the innovation period is just one among several periods of the short run. The exploration of an adaption path therefore may require more than the investigation and description of its beginning. According to the paper cited previously, though, it is the „instant effect" of process innovation that „shapes the subsequent behaviour of the system" (Haas, 2015, p. 15). In order to discover and illustrate the shape of this subsequent behaviour the simulation of an agent-based model seems more suitable than an analytical framework consisting of mathematical equations only.

	innovation type	bias	Δg_x	Δg_L
A	capital saving and labour using	$\phi_k < 0, \phi_l > 0$	-	0
B	pure capital saving	$\phi_k < 0, \phi_l = 0$	0	0
C	dominantly capital saving	$\phi_k < \phi_l < 0$	+	0
D	neutral factor saving	$\phi_k = \phi_l < 0$	+	0
E	dominantly labour saving	$\phi_l < \phi_k < 0$	+	-
F	pure labour saving	$\phi_l < 0, \phi_k = 0$	+	-
G	labour saving and capital using	$\phi_l < 0, \phi_k > 0$	-	-
R	none	$\phi_l = 0, \phi_k = 0$	0	0

Table 1: Causal effects in the innovation period

2.1 Diffusion in the adopted framework

According to Haas (2015, pp. 15–20) the diffusion process can be subdivided in up to three phases following the innovation period. Only if the capital bias of the corresponding technical change outstrips the labour bias, a re-absorption phase is implied. Within this phase unemployed workers, dismissed by the innovating firm in the innovation period, gradually get re-absorbed due to a growing investment and capital stock. The re-absorption phase fails to occur or ends when aggregate labour demand at least equals or even exceeds the working population. The predation phase begins. Within this phase the attraction of workers to the innovating firm finally affects the workforce available to the non-innovating firm. From now on the non-innovating firm is not able to fully utilize its capital stock and sooner or later will be confronted with an ongoing declining output. The diffusion process comes to an end at the transition to the restoration phase. In this phase the growth of the innovating firm meets the limit given by population growth and a new steady state is established.

Focussing on a pure labour saving innovation (F) allows an illustration of all potential phases of the adaption path (see fig. 1). The illustration captures the evolution of three indicators. First, it depicts the periodical unemployment rate. Secondly and thirdly, it shows the diffusion of the production method as the corresponding share of attributable output and goods supply. The difference between these two indicators reflects the difference among the profit led investment by firms.

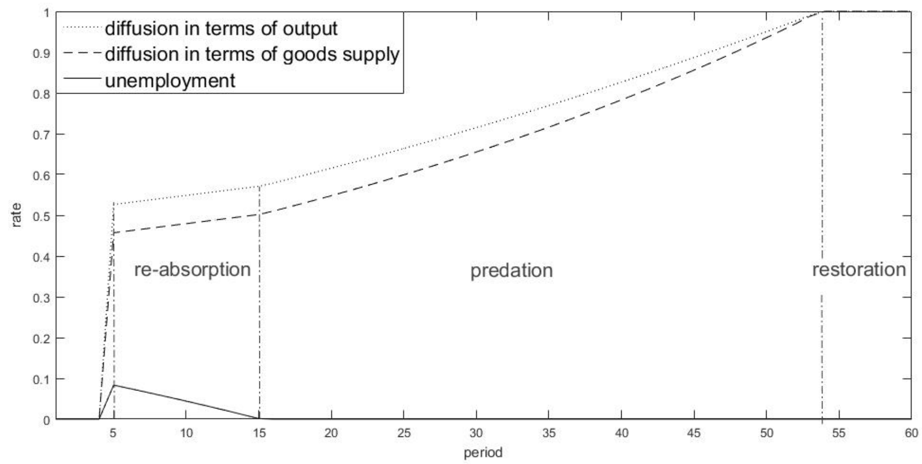


Figure 1: Exemplary diffusion of pure labour saving technical change within the adopted framework

2.2 Investment in the adopted framework

Investment (i) within the adopted framework principally depends on expectations (see eq. 1, acc. Haas, 2015, p. 7, eq. 6b). A firm invests according to its expected profit rate (r^e) and its actual capital stock (K), but it always considers the limit given by population (N) and technology – the letter is described by capital (k) and labour (l) input coefficients of the production method. In other words, firms aim to invest at least that share of individual production that should not need to be sold to cover the payment of wages. At the same time firms try to avoid obvious overcapacity. Therefore, it restocks capital not more than the entire population would be able to apply according to the individual production method.

$$i_{f,t} = \min \left\{ x_{f,t}; r^e_{f,t} K_{f,t}; \frac{\left(1+\hat{N}\right) k_f}{l_f} \frac{N_t}{M_t} - K_{f,t} \right\} \tag{1}$$

Additionally, or rather first of all, the firms also have to consider the periodical output produced (x). Although this dependency is missing within the analytical formulation of the cited paper, it is explicitly stated by the assumption that investment is directly taken from periodical output – thereby reducing goods supply (s, see eq. 2).

$$s_{f,t} = x_{f,t} - i_{f,t} \tag{2}$$

However, there is even more. Focussing on given constraints, the innovating firm in the model implicitly also considers the prospective degree of competition. A firm that expects the whole population as individually attractable labour supply obviously does not fear a serious competitor in the labour market. Indeed, to extend the analytical framework to a higher amount of innovating firms while still ensuring that the system follows the expected paths to a new and stable steady state, one has to explicitly implement the corresponding consideration in the investment function: the limit has to be given by the total size of population divided up among the expected number of innovators (M) as long-term competitors out of a total number of firms (F). Otherwise too high investment can cause crucial delay in the occurrence of the steady state market price and the supply of the consumption good. The previously depicted results as well as upcoming simulations are based on the adopted assumption of just one innovator out of two firms (see tab. 2).

$M_t = 1$	$F_t = 2$

Table 2: Exogenously set number of innovators and firms

In a solely analytical point of view this does not seem all that relevant as long as there is a systemic tendency to the steady state. The expected profit rate within the model not only depends on the wage rate, expected goods price (p^e) as well as on the input coefficients for labour and capital. The expectations about the profitability of every single bound unit of capital also considers the capital utilization rate – the relation between actual output and potential output determined by capital stock and capital input coefficient (see eq. 3, acc. Haas, 2015, p. 6, eq. 4).

$$r^e_{f,t} = \frac{1 - \frac{w_f}{p^e_{f,t}} l_f}{k_f} \frac{x_{f,t}}{\frac{K_{f,t}}{k_f}} \tag{3}$$

Any overcapacity by a firm then also implies underutilization which is followed by a reduction of the expected profit rate. A sufficiently low expected profit rate and the stated linear relationship in turn imply a corrective decrease of investment. So far the model looks like the application of an old Classical hypothesis in a Post-Keynesian manner (Hein, 2004, pp. 191-192).

2.3 Sequences of corresponding simulations

Translating this approach into an agent-based model requires some timeline of events. In every simulated period (t) the following decisions take place in sequential order:

1. firms determine their actual capital stock and their labour demand aiming full utilization according to their production method (see eq. 5 and 6 in app. A)

2. firms hire workers according to their labour demand; the innovating firm moves first, the non-innovating firm may face an insufficient supply (see eq. 7 and 8 in app. A)

3. firms produce their output according to their production method, capital stock and hired workforce (see eq. 9 in app. A)

4. firms invest according to the previous subsection; the individually output produced is partly reserved as capital good for the next period, the residual is provided to the consumption good market as goods supply (see eq. 1, 2 and 3 in subsec. 2.2)

5. nominal demand is determined by the wage bills of firms; consumption good's price is determined by nominal demand relative to goods supply (see eq. 10 and 11 in app. A)

6. firms sell their goods supply and adapt their expectations according to the market outcome (see eq. 12 in app. A)

2.4 Settings of corresponding simulations

Although the following analysis allows qualitative interpretations only, the agent-based model is based on quantitative settings. This concerns the input coefficients for labour and capital used by the old production method as well as the uniform output and wage rate (w) within the starting period and therefore original steady state. Furthermore, the population growth rate ($\hat{N}$) and the relative wage differential ($\hat{w}$) are exogenously given (see tab. 3).

As the implications are sensitive to all these quantitative settings, any such setting has to be understood as a practicable example for illustrative purposes. Once such setting is found, only the, also exogenously, chosen factor bias varies between the simulated types of innovation (see tab. 4).

$k_{f,0} = 10$	$l_{f,0} = 1$	$x_{f,0} = 10000$	$w_{f,0} = 1000$	$\hat{w} = 0.01$	$\hat{N} = 0.05$

Table 3: Exogenously given variables and parameters fixed for all settings

scenario	A	B	C	D	E	F	G	R
ϕ_k	-0.25	-0.25	-0.25	-0.25	-0.1	0	0.1	0
ϕ_l	0.1	0	-0.1	-0.25	-0.25	-0.25	-0.25	0

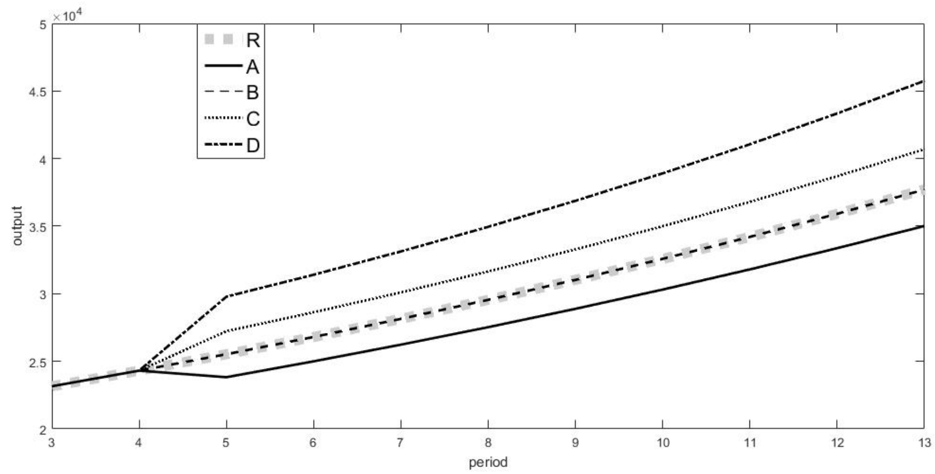
Table 4: Combinations of factor bias varying between scenarios

It has to be remarked that all scenarios of innovations (A to G) have to satisfy the choice of technique criteria. That means that the input coefficients of the new production method allow for a higher profit rate given the prices in the innovation period (Kurz and Salvadori, 1995, p. 50). This is ensured by the chosen parameters for input coefficients and factor bias. A scenario that does not consider any positive or negative factor bias (R) additionally provides the reference path the economy would have taken in absence of any innovation. In the following, the evolution of variables is depictured for several simulations.

2.5 Growth in the adopted framework

Focussing on the case of capital saving and labour using technical change (A), the simulation first shows that a corresponding innovation not only temporarily reduces growth rate, but sustainably moves the economy onto a lower growth path in absolute terms of output (see fig. 2). Simultaneously a look at the evolution of goods supply confirms that missing output growth in that case is rather the consequence of the reduced need for investment in produced capital. There is no threat for wealth provided by consumption (see fig. 3).

On the other side of the spectre that threat exists. Innovations with capital bias higher than labour bias (E, F, G) temporarily lead to a decrease in goods supply before the reference path gets outperformed. It can be stated: the larger the bias on capital the later the innovation-related increase in goods supply occurs (see fig. 3). Additionally the relative smallness or even absence of labour bias bears the risk of technological unemployment. While the adopted framework promises a tendency towards full employment, the illustrations show that there may be a remarkable delay of the occurrence



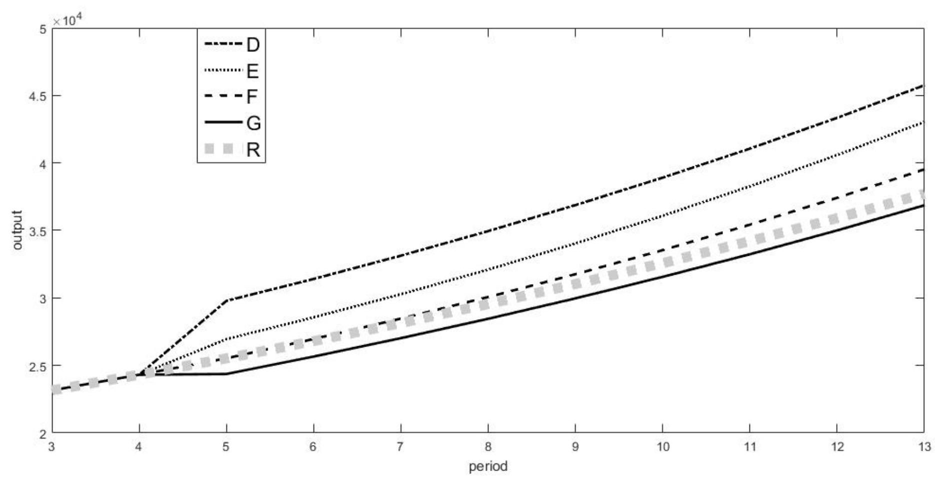
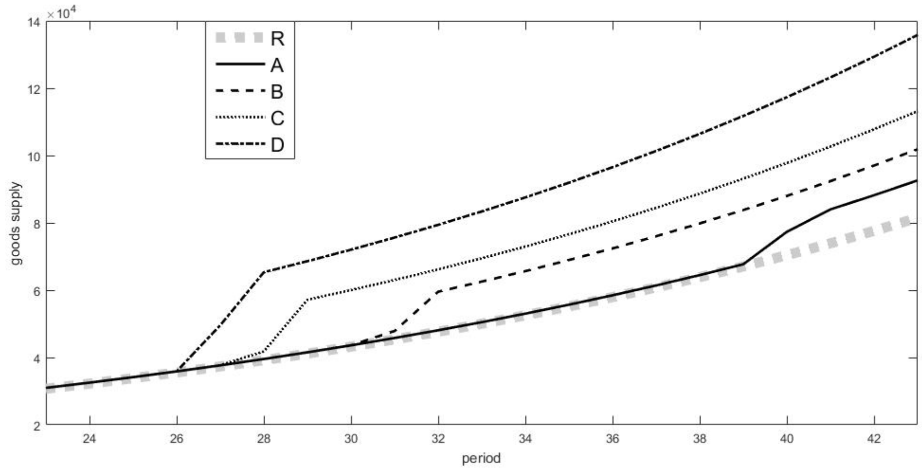


Figure 2: Output in the adopted framework

of the long-run steady state (see fig. 4). As goods supply is a residual of output not invested in capital stock, a crucial part of the so far illustrated short-term decline in total goods supply is due to investment of the innovating firm. The price of the consumption good still remains stable because any unemployment reduces the wage bill and therefore the total nominal demand. However, sooner or later the production of the innovating firm catches up leading to the re-absorption and predation of workers. When finally investment and growth is reduced to the steady state level deter-



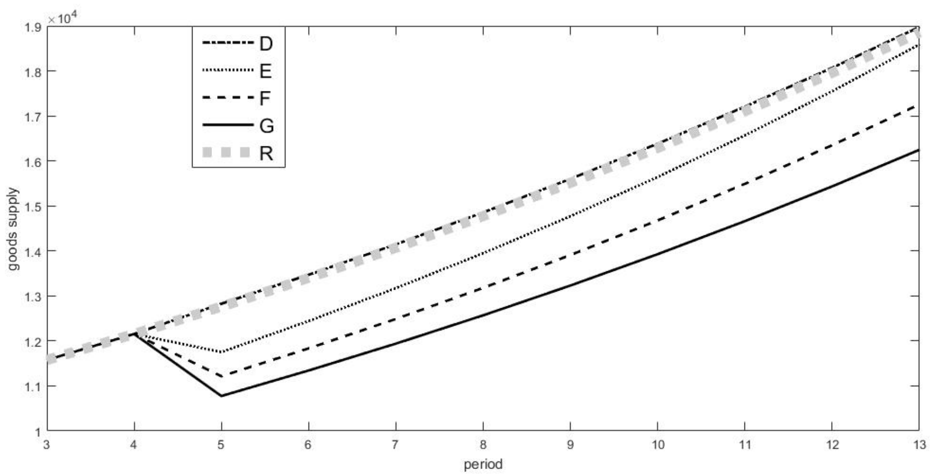


Figure 3: Goods supply in the adopted framework

mined by population growth, the increasing goods supply also leads to the fall in market price. With the corresponding delay the economy reaches the previously mentioned restoration phase.

For a pure capital saving technical change (B) in turn, a perspective restricted to output and employment suggests no delay at all, because there is no change in the level of output and employment due to innovation. The production of output is limited by the supply of workers, which in turn is limited by the constantly growing population. The scope for individual

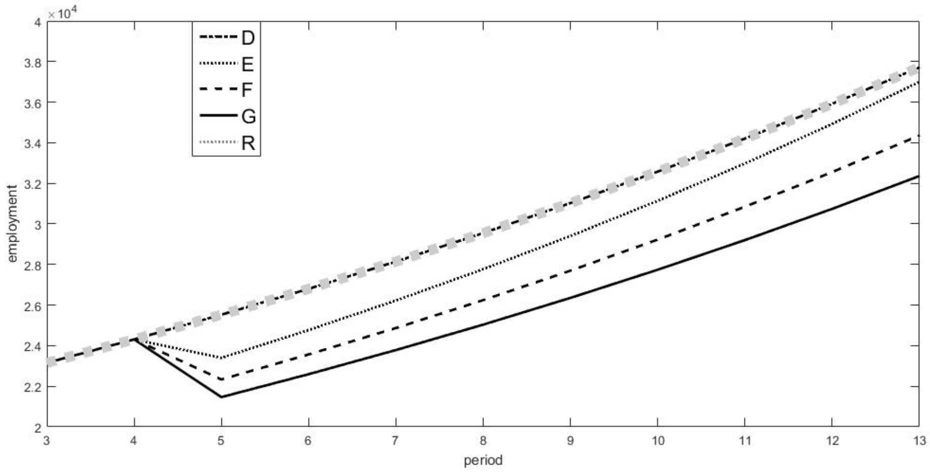


Figure 4: Employment in the adopted framework

growth, though, remains and the innovating firm correspondingly invests during the predation phase. As for other innovations with labour bias larger than or at least equal to capital bias (A, B, C, D) the reduced need for capital in production does not leave more output for consumption until the capital stock of the innovating competitor is about to reach the capacity to employ the whole population – leaving no workers for the now unutilized capital of the non-innovating firm.

3 Some reconsiderations

So far, the adopted framework allows for some interesting insights as well as illustrations. However, some of the assumption have to be reconsidered – especially with regard to investment as the driving force of growth.

3.1 Discussion on Acquisition

After diffusion is completed, the capital of the non-innovating firm remains unutilized because of the plausible assumption that once installed capital cannot be dismantled or transformed to serve another purpose. Haas (2015, p. 10) himself though already mentions the contradiction within the adopted framework: the innovating firm applies its old capital stock by the new production method.

This would rather imply that once installed capital could be applied by both production methods. In such a case, the owners of the non-innovating firm are well advised trying to sell their capital stock to the innovating firm instead of watching their market share shrinking period by period in the predation phase. To some extent, such an acquisition seems to be suitable also for the owners of the innovating firm. Otherwise, they have to invest their own output for several periods to reach the corresponding level of production and market share.

Allowing for such an acquisition would therefore reduce investment in terms of reserved output by the innovating firm as well as additionally avoid ongoing investment by the non-innovating firm during the otherwise observed predation phase. The detailed implications for the economy as a whole still depend on the type of technical change. If capital bias exceeds labour bias (E, F, G) even another phase of unemployment could occur. Nevertheless, like for all types of innovation such an acquisition would mainly accelerate diffusion. The economy would reach the new steady state earlier in time.

3.2 Discussion on Competition

However, firms could anticipate that reaching the restoration phase also implies a fall in price and thereby in extra profits. Then the innovating firm's motivation in favour of acquisition can be questioned. This dilemma hints on further critical points of the adopted assumptions.

The competitive price setting at the market does not seem to be an appropriate assumption for a model considering two firms only (Snyder and Nicholson, 2008, p. 521). As long as identical firms face identical access to all markets and follow identical decision rules, though, a proportional increase of the number of innovating as well as non-innovating firms does not change the results qualitatively. The two firms then represent an agglomerate of a sufficiently large number of identical firms competing with each other and therefore acting as price takers.

This apparent justification opens the discussion for critique of representative agent approaches neglecting heterogeneity and a main characteristic of systems – they are more than the sum of their components (Potts, 2001, p. 44). Even if this fundamental critique may set aside and the remaining firm in the model truly represents a sufficiently large number of competitors, the adopted framework implies that an innovation halves the number of firms represented in the market. This conforms to Schumpeterian expectations concerning a continual decrease in competition (Stapleford, 2001,

p. 161). The model itself therefore suggests that there will be a point in time when firms escape the role of price takers and should consider the present and future degree of competition for their investment. The adopted framework misses dynamic consistency.

3.3 Discussion on Utilization

Assuming competitive price setting, though, is important to preserve the inner logic of the decision rule applied. The expected price determines the expected profit rate, which in turn determines investment, which in turn indirectly determines periodical output aspired by firms: Full utilization of cumulated investment in terms of capital stock appears to be profit maximizing because firms act as price takers producing at constant returns to scale. As long as firms retain some output for investment, the price of the consumption good is avoided to fall to the level of the wage rate. Marginal revenue then exceeds marginal costs for all feasible levels of output. As capital is fully conserved independently of its use, unutilized capital implies forgone profit and thereby a corresponding decline of the profit rate.

Furthermore, there is no alternative use for profits than investment into the own capital stock. The adopted framework therefore damns profitable firms to grow independently of their long-term potential – never ever shrinking because capital is fully conserved for free.

3.4 Discussion on Depreciation

Free conservation of capital means that there is no depreciation. The incorporation of depreciation would not only support the assumption of firms aiming at full utilization, but neglecting depreciation also contradicts economic practice as well as business administration (Wöhe and Döring, 2008, pp. 752-762).

In the model depreciation would not only allow the non-innovating firm to shrink. The incorporation would rather be reflected in lower growth rates since parts of the investment would just compensate for depreciation instead of building up additional capital stock. The correspondingly slower diffusion would also imply that the occurrence of the new steady state for all types of innovation will be delayed.

Additionally, if once installed capital cannot be dismantled, depreciation would provide a inevitable reason for stepwise substitution. The combined incorporation would imply a rather smooth adaption path for the economy as a whole as well as for the firms in the corresponding sector.

3.5 Discussion on Liquidity

As there is only one sector, where all and only wages are dedicated to consumption, aggregate revenue is limited as well as determined by the aggregate wage bill. The individual goods supply only determines which share of the aggregate revenue goes to which firm. When production method and individual goods supply can differ between firms, individual revenue does not necessarily equal individual costs. Instead, the model leaves some scope for individual financial surplus or deficit.

In the adopted framework a corresponding positive or negative change in liquidity occurs at the end of the predation phase. The innovating firm increases goods supply at the cost of investment when it is about to reach its maximum capacity determined by population. Then the market price of the consumption good falls for the first time. The individual revenue of the non-innovating firm does not cover the periodical costs captured by the individual wage bill. This implies a shortfall of liquidity for the non-innovating firm and an equally sized surplus for the innovating one.

The practical outcome of the initially adopted framework does not crucially depend on the consideration of liquidity. In the adopted framework the nominal market price falls within only two periods onto the new steady state level. In the second of these periods the non-innovating firm already fails to attract workers and thereby is forced out of the market.

Still, there remains some debt and as capital cannot be transformed to serve another purpose, the scope for liquidation and repayment seems to be missing. Moreover, according to economic practice growth of internal finance also directly affects investment decisions and financial variables should not be excluded from investment functions (Basu and Das, 2015, p. 29, Wöhe and Döring, 2008, pp. 519-520).

3.6 Discussion on Subsidy

Financial aspects are important on the demand side as well. As nominal demand for consumption goods within the model is determined by wages and thereby the wage bill only, it implicitly assumes that either the unemployed part of the population does not consume or that the employed part of the population shares its consumption goods with the unemployed. The latter can be understood as intratemporal redistribution of income. This would imply a government who sets tax rates periodically in a way that its tax income exactly equates the nominal demand for consumption by unemployed workers.

Instead, government rather tries to maintain stable tax rates over time and finances unemployed benefits intertemporally by budget surpluses generated during booms (Barro, 2008, p. 358). The adopted framework, though, analyses the adaption path from one steady state to another. Within these steady states the framework does not allow for booms and busts. An equilibrium approach indeed often is seen as best practice to analyse economic effects in short and long run despite the fact that reality is characterized by fluctuations and business cycles (Barro, 2008, pp. 5, 173-174). However, there can also be found a lot of critique on the attempt of analysing out of equilibrium behaviour with an equilibrium approach (Potts, 2001, pp. 26-29).

Focussing on output in the adopted framework only two innovation types generate a situation that could be interpreted as recession in terms of a slow down of economic activity. As already mentioned within the corresponding subsection the reduced growth rate of output in case of a capital saving labour using technical change (A) does not automatically imply a recession but rather a more effective use of material resources. Labour saving capital using technical change (G), though, may imply not only reduced output, but also unemployment. The latter is implied also by other innovation types described by a capital bias larger than labour bias (E,F).

Deficit spending in terms of unemployment benefits would stabilize total nominal demand and thereby positively affect market price and expected profit rate as the new production method is applied. This in turn would positively affect investment. Increased investment, though, not only positively affects output growth but would lead to a increased temporary reduction of goods supply. This again leads to an increase in nominal market price and so on and so forth. Although the accelerated investment and output growth would imply an earlier occurrence of the outperforming steady state, the re-absorption and predation phase would be branded by postponed wealth and inflation. The consequential insight would be that there is limited scope for demand side transfer policies when capital capacity is fully used already.

3.7 Attempt on Utilization

As capacity plays that an important role and full utilization is aspired by firms in favour of high profit rates, finally a closer look on the investment decision is suggested. Letting the utilization rate determine the expected profit rate is just a necessary step to avoid an extent of investment that is not fundable by periodical profits. Another question is whether a firm wants to invest all expected profits or once again considers utilization and potential overcapacity. Indeed, empirical studies suggest a separate consideration of the capital utilization rate (Basu and Das, 2015, p. 29). One rather simple way to incorporate the capital utilization rate also in the investment function is to let it directly determine the proportion of expected profits that is invested (see eq. 4).

$$i^{\cdot u}_{f,t} = \max\left\{0; \min\left\{x_{f,t}; r^{e}_{f,t} K_{f,t} \frac{x_{f,t}}{\frac{K_{f,t}}{k_{f,t}}}; \frac{\left(1+\hat{N}\right) k_f}{l_f} \frac{N_t}{M_t} - K_{f,t}\right\}\right\} \tag{4}$$

This reflects nothing more than the idea that a firm cuts investment as long as it has capacity left anyway. This is consistent with the effort to prevent a fall of the profit rate. The ceteris paribus implications of an application on previous settings (see tab. 3 and 4) are crucial, though. As there is no alternative use for capital and the investment decision directly affects goods supply it also influences the market price of the consumption good. This in turn affects the expected profit rate which in turn determines investment. To this effect the implementation implies that price becomes unstable much earlier in time and its adaption occurs rather continuous over a few periods. A corresponding evolution is depicted exemplarily for the simulation of pure capital saving technical change (B$^{\cdot u}$, see fig. 5). In general, a similar loop downward also occurs for all other scenarios. However, its exact form and its impact on the evolution of goods supply crucially differs depending on factor bias.

For those innovation types described by a labour bias larger than capital bias (A$^{\cdot u}$,B$^{\cdot u}$,C$^{\cdot u}$) the new production method immediately implies labour shortage. The non-innovating firm therefore faces overcapacity and reduces its investment which increases goods supply. This in turn initiates a fall in market price and thereby a reduction of expected profit rates. To this effect reduced investment directly increases goods supply in the very short run, but leads rather soon and sustainably to lower growth – partly even beyond the reference path occurring in absence of innovation (R, see fig. 6).

While for technical change described by a labour bias lower than capital bias (E$^{\cdot u}$,F$^{\cdot u}$,G$^{\cdot u}$) the undercutting of the reference growth path still seems to be a temporary issue, the medium-term growth still lies beneath those paths generated by the simulation based on purely profit led investment (E,F,G). On the one hand, a look on the evolution of the unemployment rate therefore may underline the market economy's dependence on the investment decision (see fig. 7).

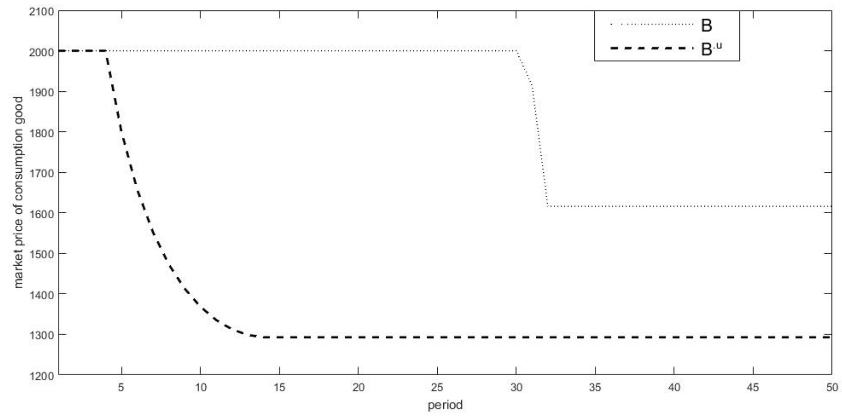


Figure 5: Comparison of market price adaption induced by pure capital saving technical change

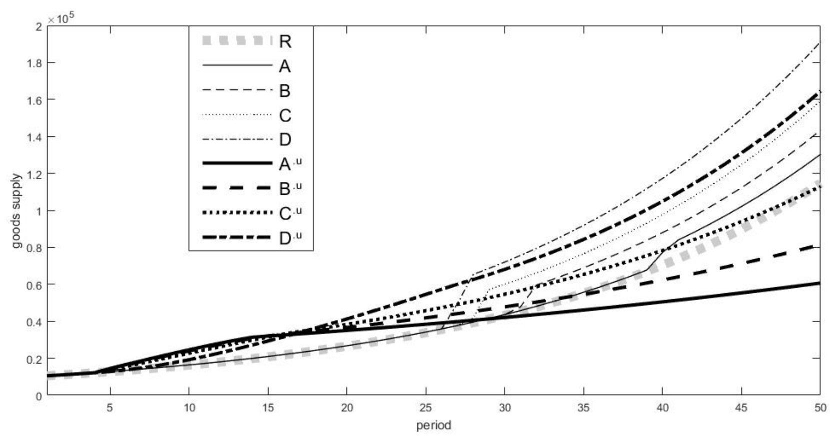


Figure 6: Comparison of goods supply for technical changes with balanced or dominating labour bias

On the other hand, the illustration just point out the relevance of adopted assumptions in combination with a slight adaptation in regard to investment – for example that a once forced out firm remains lurking and distorting because of denied shrinking.

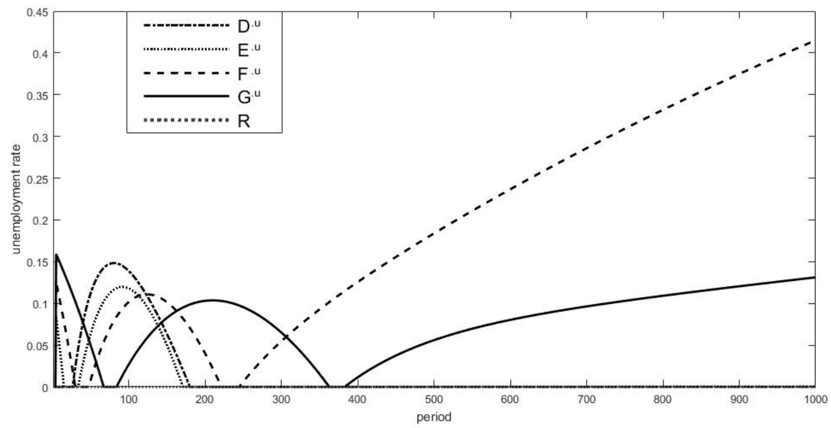


Figure 7: Unemployment rate for technical changes with balanced or dominating capital bias within the adapted framework

4 Conclusions

The attempt to extend the benchmark model stepwise and let firms explicitly consider the utilization rate in their investment decision (see subsec. 3.7) shows the following: a strongly simplified framework may become strongly distorted by just one simple adaptation. Results may become even more washy as well as biased.

Discussions and similar – but not illustrated – attempts to apply adaptations on other critical points (see subsec. 3.1, 3.2, 3.3, 3.4, 3.5 and 3.6) show: even if the adopted framework absorbs a stepwise extension, the effects of its isolated incorporation may not be pioneering – what lengthens or shortens adaption phases and what increases or decreases the extent of variables like unemployment, investment or goods supply could often be deducted intuitively.

Remaining simplifications rule out many sources for dynamics and leave the challenge to translate the implications of a one-sector model to a multi-sectoral world. Instead of a stepwise extension of the adopted framework, risking to lose explanatory power while hardly gaining validity for conclusions, the paper on hand therefore finally suggests that future work on the topic of innovation should tie in with more complex and comprehensive approaches dealing already with the discussions above (Dosi, Fagiolo, and Roventini, 2006; Dosi, Fagiolo, and Roventini, 2010; Dosi et al., 2013; Dosi et al., 2015).

Finally, it can be stated that Haas (2015) not only gainfully uses the adopted framework of Classical and Post-Keynesian equations, but also seems to outbid its potential in regard to the investigated topic.

Appendix

Some further equations may help to describe the quantitative processes executed in the course of periodical procedures. In the agent-based model these equations partly describe decision rules for firms and partly serve as description for the systemic interdependence of individual state variables.

A adopted framework only

$$K_{f,t} = K_{f,t-1} + i_{f,t-1} \tag{5}$$

$$L^d_{f,t} = \frac{K_{f,t} l_{f,t}}{k_{f,t}} \tag{6}$$

$$L_{f \in M_t,t} = L^d_{f \in M_t,t} \tag{7}$$

$$L_{f \notin M_t,t} = \min\left\{ L^d_{f \notin M_t,t}, N_t - L_{f \in M_t,t} \right\} \tag{8}$$

$$x_{f,t} = \min\left\{ \frac{K_{f,t}}{k_{f,t}}, \frac{L_{f,t}}{l_{f,t}} \right\} \tag{9}$$

$$y_t = \sum_{f=1}^{2} w_{f,t} L_{f,t} \tag{10}$$

$$p_t = \frac{y_t}{\sum_{f=1}^{2} s_{f,t}} \tag{11}$$

$$p^e_{f,t+1} = p_t \tag{12}$$

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