Socially Efficient Stabilization of Industrial Cycles via Organic Profit-sharing and its Crucial Tension

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Supplementary materials to the paper

The Figures and Tables below have numbers continued in relation to those in the paper. The numbers of the equations remain the same. See the listing of the variables in Table 1 in the paper.

Super-critical Andronov – Hopf bifurcations and self-sustained industrial cycles in Z-1

The standard characteristic equation linked to the Jacoby matrix for stationary state E_b in Z-1 is written as

$$\lambda^3 + a_2\lambda^2 + a_1\lambda + a_0 = 0.$$

Parameter b from (7) has been taken as the control parameter. For $b = b_{critical} = 1800 > b_0 = 711.44$, there is transition to a limit cycle vicinity (up to years 3000–3030) from the initial phase vector $y(2009)$ in scenario (exploratory) 1 b. The period of oscillations either close to the initial vector or near E_b is about $5.75 < 2\pi / \sqrt{a_1(b_0)} \approx 8.016$ (years). Ryzhenkov (2016) provides the reader with further analytical details on a particular Andronov – Hopf bifurcation.

The upward arc of the cycle comprises three fourth of the cycle length, the downward arc – the remaining one fourth. Such asymmetry is a common property of realistic business cycles models emphasised by Blatt (1983).

According to Table 3, in scenario (exploratory) 1 b after 2020, the first completed cycle stretches from the 3rd quarter of 2021 (2021.75) through the 2nd quarter of 2027 (2027.5) for about 6 years. The passing of the pre-crisis local minimum of net output happens at the very end of recovery, whereas depression, as the next phase, continues until the locally maximal capital-output ratio, is reached in 2023.0. The previous locally minimal capital-output ratio is to be observed during the boom in 2020.0. The next crisis will last from 2027.75 until 2029. No repercussions from Covid-19 have been taken into account unlike (Ryzhenkov, 2020).

Table 3. Duration of phases of the two adjacent industrial cycles (quarters/ years)

Boom	Crisis	Depression	Recovery	Boom	New cycle
2018.25–2021.5	2021.75–22.75	2023.0	2023.25–23.75	2024.0–2027.5	2021.75–2027.5
14/3.5	5/1.25	1/0.25	3/0.75	15/3.75	24/6

The drop of employment ratio v heralds the soon onset of the crisis (two quarters later) with a decline in net output q; on the other hand, the bottoming of net output opens the way to increases in employment ratio (three quarters later).

Relative capital over-accumulation encompasses 2020.25–23.25, absolute capital over-accumulation of type 1 presides over 2020.5–23.5, absolute capital over-accumulation of type 2

continues during 2021.5–23.0. A succession of local extrema of indicators' growth rates over 2018.25–27.5 is presented in Table 4.

Table 4. Extremes of indicators' growth rates for the abbreviated phases of subsequent industrial cycles in scenario (exploratory) 1 b, 2018.25–27.5

	Boom started 2018.25					Crisis 2021.75–22.75	Depression 2022.75–23.0	Recovery 2023.25–23.75			Boom 2024.0–27.5	
	18.75	20.0	20.25	21.25	21.5	21.75	23.0	23.25	23.5	23.75	24.0	24.75
q	max	↓	↓	↓	0	min	0	↑	↑	↑	↑	max
$(1-u)/s$	max	0	↓	↓	min	↑	↑	0	↑	↑	↑	max
$(1-u)l$	max	↓	0	↓	↓	min	↑	↑	0	↑	↑	max
$(1-u)q$	max	↓	↓	0	↓	min	0	↑	↑	↑	↑	max
v	max	↓	0	↓	↓	min	↑	↑	↑	0	↑	max

Note. The phases of cycles are presented fragmentally for condensing the essentials.

A comparison of Z-1 and S-1 stock-and-flow structures

Tables 5 and 6 demonstrate differences in the condensed causal structures of two models Z-1 and S-1. First, due to organic profit-sharing the two dominant positive feedback loops of the 1st order from Z-1 are converted into negative in S-1. Second, the negative partial derivative of u with respect to z and the negative partial derivative of z with respect to u are transformed into positive ones. Third, two negative feedback loops of the 3rd order are reshaped into positive ones.

Table 5. The comparison of intensive feedback loops in Z-1 with those in S-1

Order	Feedback loops in Z-1 at stationary state E_b	Feedback loops in S-1 at stationary state S_X
1st	R1 of length 1 $u \xrightarrow{+} \dot{u}$ R2 of length 1 $z \xrightarrow{+} \dot{z}$ B2 of length 1 $v \xrightarrow{-} \dot{v}$	B1 of length 1 $u \xrightarrow{-} \dot{u}$ B2 of length 1 $v \xrightarrow{-} \dot{v}$ B3 of length 1 $z \xrightarrow{-} \dot{z}$
2nd	B1 of length 3 $u \xrightarrow{-} \dot{v} \longrightarrow v \xrightarrow{+} \dot{u}$ B3 of length 3 $v \xrightarrow{-} \dot{z} \longrightarrow z \xrightarrow{+} \dot{v}$ R3 of length 3 $u \xrightarrow{-} \dot{z} \longrightarrow z \xrightarrow{-} \dot{u}$	B4 of length 3 $u \xrightarrow{-} \dot{v} \longrightarrow v \xrightarrow{+} \dot{u}$ B5 of length 3 $v \xrightarrow{-} \dot{z} \longrightarrow z \xrightarrow{+} \dot{v}$ R1 of length 3 $u \xrightarrow{+} \dot{z} \longrightarrow z \xrightarrow{+} \dot{u}$
3rd	B4 of length 5 $u \xrightarrow{-} \dot{z} \longrightarrow z \xrightarrow{+} \dot{v} \longrightarrow v \xrightarrow{+} \dot{u}$ B5 of length 5 $v \xrightarrow{-} \dot{z} \longrightarrow z \xrightarrow{-} \dot{u} \longrightarrow u \xrightarrow{-} \dot{v}$	R2 of length 5 $u \xrightarrow{+} \dot{z} \longrightarrow z \xrightarrow{+} \dot{v} \longrightarrow v \xrightarrow{+} \dot{u}$ R3 of length 5 $v \xrightarrow{-} \dot{z} \longrightarrow z \xrightarrow{+} \dot{u} \longrightarrow u \xrightarrow{-} \dot{v}$

The strongest greed feedback loop R2 in Z-1 is overcome in S-1 with respective feedback loop B3. The other greed feedback loop R3 in Z-1 is transformed into R1 in S-1. These transformations abate relative and absolute capital over-accumulation under state-monopoly capitalism.

Table 6. The number of specific feedback loops in Z-1, and S-1

Order	First		Second		Third		Total	
Polarity	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive
Z-1	1	2	2	1	2	0	5	3
S-1	3	0	2	1	0	2	5	3

Stabilization policy in simulation experiments

The starting year numbered for certainty 2009 in the simulation runs belongs to a crisis phase. It is the appropriate moment for starting the stabilization policy in S-1. Scenario (stabilization) 2 smooths out business volatility of scenarios (exploratory) 1 and 1 b originated in Z-1.

Table 7 posts the magnitudes of the respective roots of the characteristic equation corresponding to the stationary state S_X (11) and Jacoby matrix for this state in the linearized S-1. Consequently, the stationary state S_X happens to be locally asymptotically stable focus-node under the given specifications.

Table 7. Roots of the characteristic equation for S-1 linearised at S_X

λ_1	Re(λ_2, λ_3)	Im(λ_2, λ_3)	Stationary state
–0.0040	–0.3798	±0.0841	Focus-node stable

Simulations demonstrate that this stationary state is broadly asymptotically stable in the non-linear S-1. Thus, even for distant vectors in the phase-space, S_X is the fixed-point attractor contrary to limit cycles (periodic attractors) in Z-1. The designed stabilization policy maintained by the organic profit-sharing is more robust and reliable than the stabilization policy involving the standard (mechanistic) profit-sharing critically examined in Ryzhenkov (2019).

Simulations exhibit that employment ratio v moves to target X = 0.965 without over-shooting whereby v_{max} = 0.9649. Table 8 and Figures 2–4 with multiple panels display results that are generally superior in S-1 to those in Z-1 with b = 1000 or even more so for b = 1800, respectively, in scenarios (exploratory) 1 and 1 b.

Table 8. Indicators' geometric average growth rates in two scenarios, 2010–25 with basal 2009

Indicator	Scenario (stabilization) 2	Scenario (exploratory) 1	Difference
	(1)	(2)	(3) = (1) – (2)
Output per worker a	0.021	0.018	0.003
Fixed assets k	0.023	0.017	0.006
Investment $zq(1–u)$	0.087	0.010	0.077
Profit M	0.027	0.014	0.014
Net output q	0.025	0.015	0.010
Wage w	0.020	0.019	0.001
Total wage wl	0.024	0.016	0.008
Consumption a head wv	0.024	0.016	0.008
Accumulation rate z	0.058	-0.003	0.061
Employment l	0.004	-0.003	0.007
Surplus value S	0.006	-0.005	0.011

Inequality in primary income distribution generated in Z-1 is moderately aggravated in S-1 for overcoming relative and absolute capital over-accumulation. It is worth noticing that the initial surge in investment in S-1 is accompanied by a declining capital-output ratio in tandem with a relative wage that results in higher profitability.

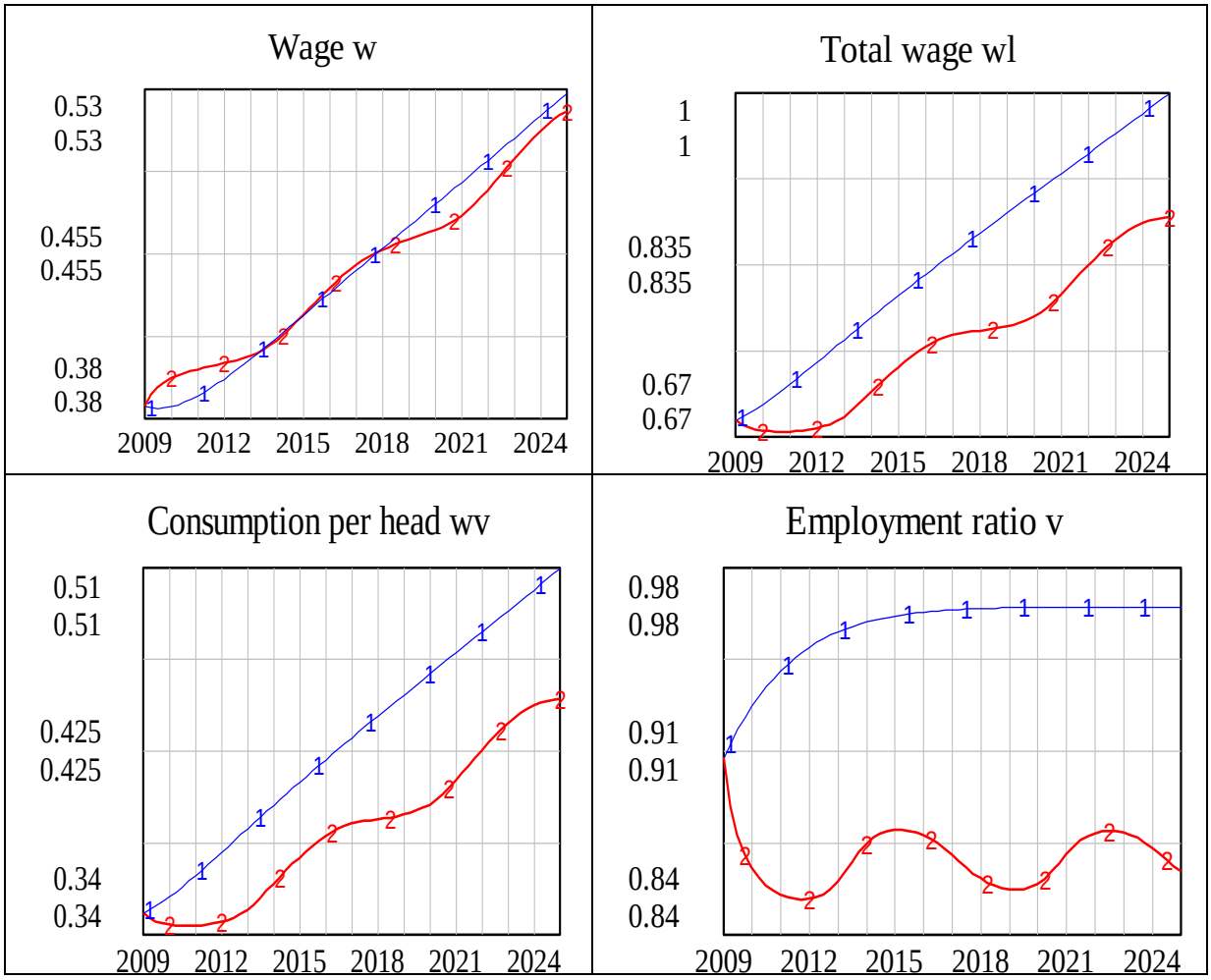

Figure 2 – Dynamics in stabilization scenario 2 (marker 1) based on S-1 and exploratory scenario 1 (marker 2) based on Z-1 with $b = 1000$, 2009–2025: wage *w*, total wage *wl*, consumption per head *wv*, employment ratio *v*

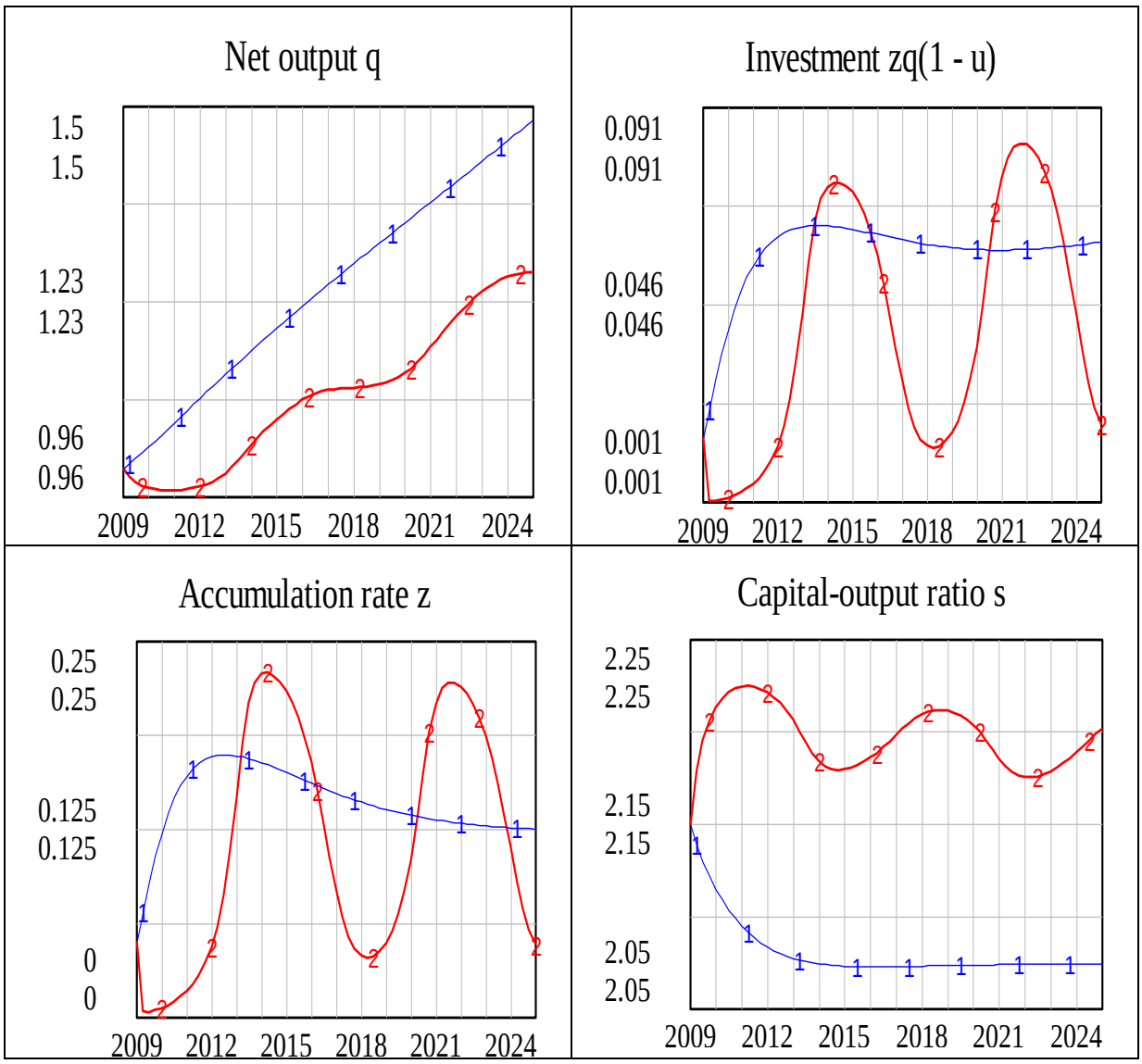

Figure 3 – Dynamics in stabilization scenario 2 (marker 1) and exploratory scenario 1 (marker 2), 2009–2025: net output *q*, investment *zq*(1–*u*), accumulation rate *z*, capital-output ratio *s*

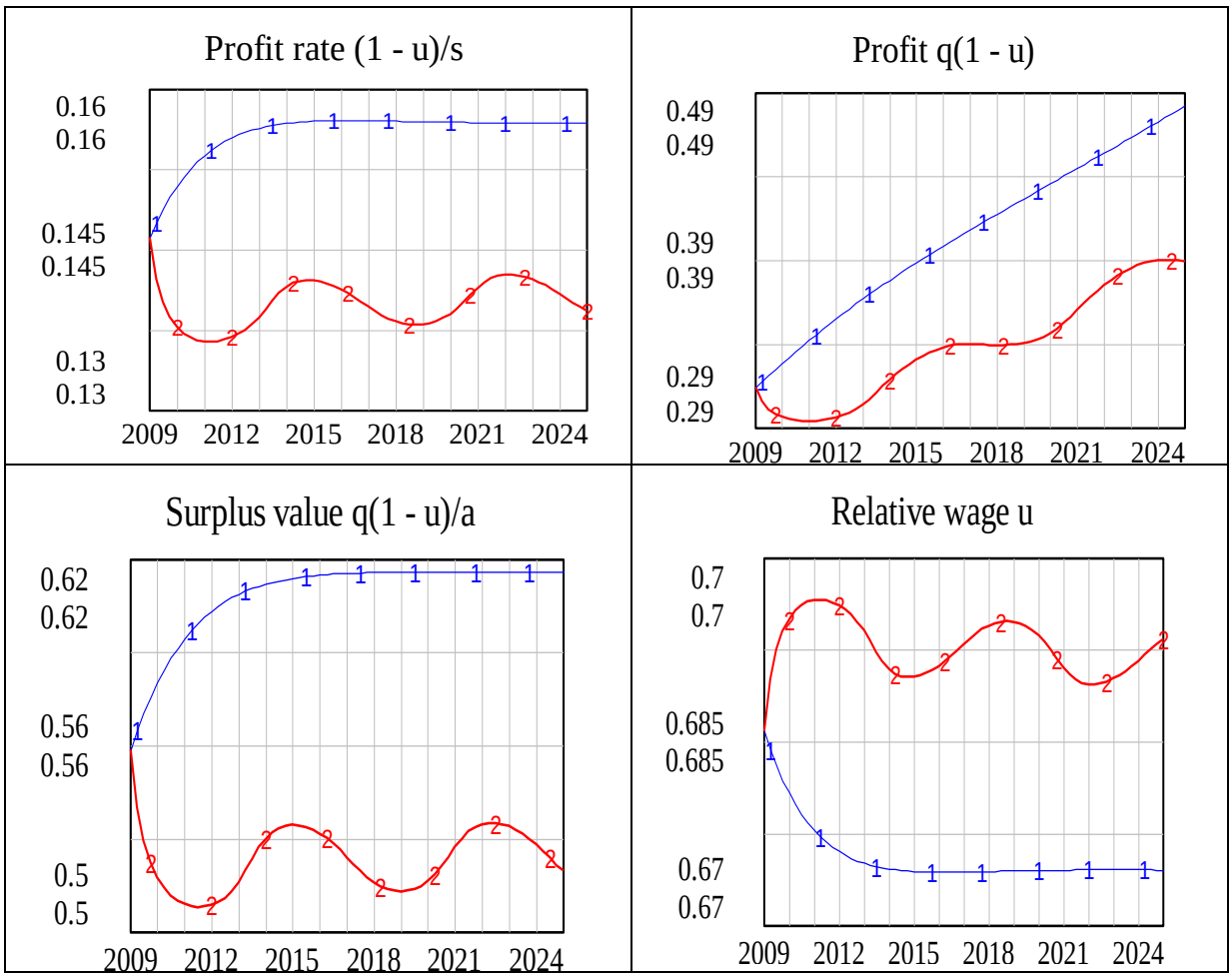

Figure 4 – Dynamics in stabilization scenario 2 (marker 1) and exploratory scenario 1 (marker 2), 2009–2025: profit rate $(1 - u)/s$, profit $q(1 - u)$, surplus value $q(1 - u)/a$, relative wage u

A transient from the initial vector $y_0 = (u_0, v_0, z_0)$ to limit cycle in Z-1 stands as a manifestation of industrial cycles that unfold under conditions in key aspects similar to those formed in the USA in aftermath of the *Great Recession* (i.e. crisis) of 2007–2009 up to 2018 (the latest year with BEA statistics – available for the author when he has been writing this conference paper – on nation-wide fixed assets, capital-output ratio, profit rate and rate of capital accumulation). In the American economy during this period there has been an upward arc of the previous record-long industrial cycle with the boom phase continued up to the 4th quarter 2019 or up to February 2020 for monthly data (NBER, 2020). The necessitated societal response to Covid-19 (the lockdown) in the spring of 2020 has aggravated the relative and absolute capital over-accumulation that already manifested in the US economy in 2019.

A crude comparison of scenario (stabilization) 2 in S-1 with an extended reproduction in the USA in 2009–2018 is rather informative (see Table 9). Notice that the given estimates of fixed assets and net investment, contrary to BEA, are abstracting from intellectual property products altogether.

Recall that a constant labour force is assumed in S-1; in the USA, labour force has been growing still its growth rate tends to decline in the long-term. The US economy has achieved about the same employment ratio in 2018 through 47.6% lower investment and 4.3% lower gain in net output.

Table 9. Indexes of indicators in 2018 relative to 2009 = 1 in scenario (stabilization) 2 in S-1 versus observed dynamics in the USA

Indicator	Scenario (stabilization) 2	USA	Difference	Relative difference, %
	(1)	(2)	(3) = (1)–(2)	(3)/(1)
Output per worker *a*	1.207	1.103	0.104	8.6
Fixed assets *k*	1.238	1.127	0.111	9.0
Investment $z(1–u)q$	3.761	1.972	1.789	47.6
Profit *M*	1.330	1.302	0.028	2.1
Net output *q*	1.283	1.228	0.055	4.3
Relative wage *u*	0.983	0.972	0.011	1.1
Capital-output ratio *s*	0.965	0.917	0.047	4.9
Profit rate $(1–u)/s$	1.074	1.155	–0.081	–7.5
Wage *w*	1.187	1.073	0.114	9.6
Total wage *wl*	1.262	1.194	0.067	5.3
Consumption a head *wv*	1.262	1.136	0.125	9.9
Accumulation rate *z*	3.436	1.516	1.920	55.9
Labour force *n*	1.000	1.051	–0.051	–5.1
Employment ratio *v*	1.063	1.059	0.004	0.4
Employment *l*	1.063	1.113	–0.050	–4.7
Surplus value *S*	1.102	1.180	–0.078	–7.1

Scenario (stabilization) 2 posts – for roughly the same profit's index – lower increment for surplus value (–7.1 %) and profit rate (–7.5%). On the other hand, the drop in relative wage is mitigated by 1.1% in relation to the observed decrease in the US economy; gains in wage, total wage, and consumption per head are about 5–10 % higher under the stabilization policy than in the real dynamics observed.

Larger domestic investments in absolute and relative terms in fixed assets are attractive for workers yet are challenging for the specific interest of the capitalist class. Table 10 illustrates how a decline in the target rate of capital accumulation negatively affects a stationary relative wage, yet its consequence for a profit rate is quite the opposite (extremely positive).

Table 10. Stationary magnitudes in Z-1 and S-1 depending on z_{goal} versus average in the US, 2009–18

Accumulation rate z_{goal}	Relative wage u_b	Capital-output ratio s_b	Profit rate R_b
0.0135 (infimum)	0	0.675	1.481
0.02	0.1784	0.8216	1
0.12	0.6646	2.0125	0.1667
1 (upper bound)	0.8838	5.812	0.0199
Average for NNP and fixed assets, current dollar, in observations (continued)			
0.079	0.666	2.041	0.164

Capital rejects, of course, the "neoclassical golden rule of accumulation" prescription of choosing $z_{goal} = 1$ since it results in the lowest rate of profit. Still even selecting assumed $z_{goal} = 0.12$ (higher than observed average 0.079) in the above scenarios with the moderate stationary profit rate $R_b = 0.1667$ (about the same as observed average 0.164) presupposes that capital's desire for maximal profitability by choosing very low $z_{goal} << 0.12$ does not socially prevail. Besides that the State and owners of capital also recognise that a higher profit rate can be accompanied by lower total profit and/or by lower total surplus value.

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