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ESSAYS ON SECULAR STAGNATION IN THE USA

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To my parents,

my strength

In omnibus requiem quaesivi, et nusquam inveni nisi in angulo cum libro.

Thomas à Kempis

"Jorge, I mean. In that face, deformed by hatred of philosophy, I saw for the first time the portrait of the Antichrist, who does not come from the tribe of Judas, as his heralds have it, or from a far country. The Antichrist can be born from piety itself, from excessive love of God or of the truth, as the heretic is born from the saint and the possessed from the seer. Fear prophets, Adso, and those prepared to die for the truth, for as a rule they make many others die with them, often before them, at times instead of them. Jorge did a diabolical thing because he loved his truth so lewdly that he dared anything in order to destroy falsehood. Jorge feared the second book of Aristotle because it perhaps really did teach how to distort the face of every truth, so that we would not become slaves of our ghosts. Perhaps the mission of those who love mankind is to make people laugh at the truth, to make truth laugh, because the only truth lies in learning to free ourselves from insane passion for the truth."

Umberto Eco - The Name of the Rose

Acknowledgements

I love reading novels, any kind of novels. Once I read this sentence that, in my opinion, suits to the proposal of this page: "*Any time you quit hearin' Sir and Mam the end is pretty much in sight*". I did not fully understand its depth at a first glance, but then I listened to the Italian version of the corresponding movie and the translators substituted thanks for Sir and please for Mam. Things looked much clearer to me and I grasped the importance of that claim.

During my journey as a PhD student, I had the opportunity (well, it is better to say the luck) to meet plenty of persons. They helped me grow intellectually, as a man, as a researcher. I will try to thank them all with these lines. I hope not to forget anybody; if not so, please forgive me. The first I need to acknowledge are my supervisors Mauro Caminati and Riccardo Pariboni, for their constant guide and support. They provided me with many careful suggestions and rigorous criticism which have greatly improved my work.

I thank the PhD Board of the joint Universities of Tuscany to have selected me as worthy to become a PhD student and, among them, I am happy to include Francesca Fabbri as member of the Administrative staff for her non-stop assistance on every paperwork.

I developed a significant part of the dissertation during my Visiting Research year in United Kingdom. I spent seven months at the University of Greenwich, in which I worked and enjoyed free time with several guys. Among them, I am indebted to my tutor Alberto Botta and to the friends I shared the office (and tables in pubs): Aya Magdi Awad, Eleftheria Panagiotopoulou, Hoang Minh Luong and Niccolò Gozzi. I was in the University of Leeds during the remaining five months. I there met Emilio Carnevali, Raverkaarn Aiemwongnukul and my flatmates Abdulaziz Ibrahim Aljanubi, Dongmin Shin, Saad Abdullah Aljohani and Wei Jen Chen. Without any of them, this year would have been boring at best. However, this list would be incomplete if I did not include Eleanor Ferguson, Deborah White, and Jo Flint: they hosted me, they took care of me and they gave me assistance whenever I needed. My aims could not unfold without them.

Helpful suggestions came from the many scholars and professors that accepted to read and comment my works. Among the others, I strongly benefitted from Alberto Russo, Alessandro Caiani, Andrea Roventini, Eugenio Caverzasi, Federico Bassi, Federico Crudu, Filippo Belloc, Gabriele Cappelli, Giovanni Bella, Leonardo Bargigli, Lorenzo Siddi, Marco Paolo Tucci, Maria Savona, Ron P. Smith, Tiziano Razzolini, Ugo Pagano and Walter Paternesi Meloni.

Marco Veronese Passarella deserves a special mention: he was my tutor during the toughest period of my project, and I spent lots of happy moments with his family which I can neither list nor forget.

I recognize I could not make a long way without the moral support of my colleagues in Siena. I thank every single student from 31st to 35th cycles but I cannot help mentioning all 33rd cycle friends: Andrea Galeotti, Asya Bellia, Chandni Dwarkasing, Erubiel Ordaz Cuevas, Giacomo Rella, Giovanna Scarchilli, Leonarda Spiranec and Mehmet Ulug. I will keep every single moment I spent with you into my heart.

Finally, I thank my parents that sustained me when all the right rules seemed to be corrupted. I dedicate these pages to you.

Needless to say, I am the only responsible for any error and omission.

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Preface and Introduction

Secular Stagnation, we have learned, is an economist's Rorschach test. It means different things to different people.

B. J. Eichengreen (2015)

The general rule is infallible, that, when by *increase of money, expensive habits of life, and taxes*, the price of labour comes to be advanced in a manufacturing and commercial country, more than in those of its commercial competitors, then that expensive nation will lose its commerce, and go to decay, if it doth not counterbalance the high price of labour, by the seasonable aid of mechanical inventions . . . *Nottingham, Leicester, Birmingham, Sheffield* &c. must long ago have given up all hopes of foreign commerce, if they had not been constantly counteracting the advancing price of manual labour, by adopting every ingenious improvement the human mind could invent.

T. Bentley (1780)

I first met *Secular Stagnation* on the columns of Project Syndicate in Fall 2018, when Prof. Summers and Prof. Stiglitz engaged in a debate on the ineffectiveness and insufficiency of monetary and fiscal stimuli set by US government to soothe the economy in the aftermath of the Great Recession. The observation of global mounting inequalities, climate changes and patchy de-industrialization all suggested me to delve into and take seriously this theory with a vaguely-apocalyptic taste into consideration, and my mind started believing that a real breakthrough in policy-making would have been necessary – hopefully sufficient – to divert mankind out of a long path of decadence.

I ascertained quite soon that a tangle of different theories and beliefs holds back to the notion of Secular Stagnation. The concept was first introduced with the pioneering work by Alvin H. Hansen (1939) to describe the bleak picture in which the United States plunged after the Great Depression of 1929; focusing on the high unemployment rate, Hansen identified Secular Stagnation with "sick recoveries which die in their infancy and depressions which feed on themselves and leave a hard and seemingly immovable core of unemployment". Though the doctrine blazed in subsequent years, it had largely dropped out of economics, especially once Hansen past away in 1975 (Backhouse and Boianovsky, 2016). However, the concept bloomed again in conjuction of the Great Recession in 2007: Prof. Summers (2014b)'s revival outlined, indeed, a situation in which changes in the economic fundamentals might have brought about a shift in the natural balance between savings and investments, such that the natural rate of interest associated with full employment would have approached negative values. The macroeconomic outcome would then have featured scarce growth, under-utilization of capacity and financial instability.

Secular Stagnation is like the Rorschach test: different things for different people. For example, Summers (2014b) tackles monetary and fiscal policy issues arising within the negative natural rate environment; Gordon (2015) and Ramey (2020) study the supply-side determinants of productivity growth and its relation with technological lulls, whereas Hein (2016) attributes Secular Stagnation to matters of Stagnation Policy, and so on. Accordingly, I move away from Summers's idea and focus on a particular stylized fact, the long-run tendency of productivity growth to fall since the early 1970s.

The dissertation analyzes the phenomenon with respect to the United States and consists of three essays. The chapters are self-contained and can be read independently of one another, though the reader can find some reference to the previous paper in the subsequent one. For this reason, I suggest reading the dissertation in an orderly manner.

In the first chapter, entitled "*Does the Secular Stagnation hypothesis match with data? Evidence from USA*", I take a historical view to see which characteristics the literature associates with Secular Stagnation find support in the data. The paper adds to the debate in four ways. Firstly, I focus my attention on US macroeconomic data about real GDP per capita, potential output, productivity measures and population since 1870, when possible. The very simple setting allows me to grasp that the slow growth in real GDP per capita as in more recent times should not be interpreted as an evidence of Secular Stagnation; rather, it represents the return to the average growth rates experienced by the USA before the Golden Age of capitalism, 1950-1972. Secondly, it is apt to talk about Secular Stagnation in terms of productivity growth, since the decline is greater than any previous shortfall. Thirdly, findings cast some doubt on Summers's hypothesis of negative natural rates, which suffers from heavy theoretical inconsistencies too; the careful analysis of data offers some evidence supporting Gordon's and Hein's stands. Moreover, this evidence shows that the use of the term *Secular Stagnation* in the literature is somewhat *misleading*, since it should concern a longer time span, possibly involving *more extended long runs*. Fourthly, the great heterogeneity of approaches implemented does not forbid complementarity or even convergence in policy implications to arise.

The second chapter, "*Secular Stagnation and innovation dynamics: An agent-based SFC model. Part I*", starts by noticing as the debate on Secular Stagnation paid little attention to the profound interplay between income distribution, innovation and productivity; in other terms, arguments lack of a *demand-side* perspective. The essay tackles that gap in the literature and sets Secular Stagnation into an agent-based computational economics (ACE) framework. I develop a model which is complex, adaptive and structural in the sense of Tesfatsion (2006): *complex*, because the system is composed of interacting units; *adaptive*, since it involves environmental changes; and *structural*, because it builds on a representation of what agents do. In this context, *agents* are an encapsulated set of data and behaviours representing an entity residing in a computationally constructed world. The model manages to replicate several well-established stylized facts of the literature. More precisely and with reference to the microeconomic level, firm's size is skewed and heavy-tailed distributed, and businesses are persistently heterogeneous in terms of productivity. Moreover, investment heterogeneity is an interesting outcome of the model. At the same time, the framework respects some empirical regularity of the macroeconomic world: a roller-coaster dynamics generates business-cycle fluctuations; the simulated time series for output and its component exhibit non-stationary properties; the unemployment rate and the investment series are more volatile than output and consumption, and cross-correlation patterns with respect to GDP are in tune with the literature.

The adoption of an agent-based perspective calls for justification. Some might ask, indeed, whether such a toolkit is really necessary or whether that modeling is able to exhibit insights *not visible* with standard methodologies, if any. I argue that, traditionally, economic agents have been modeled as rational optimizers with no role for the social context which they act upon. Moreover, such a Walrasian framework used to focus on allocation decisions and neither addressed – nor was meant to grapple with – how production, pricing and trade take place in real-world economies (Tesfatsion, 2006). ACE models observe instead economies as *complex* systems, whereby a multitude of agents repeatedly interacts with each other and gives rise to the multi-faceted stylized facts observable at the macroeconomic level. Agents are therefore designed with autonomy and the ability of self-regulating, i.e. they *learn* (LeBaron and Tesfatsion, 2008).

I then scrutinize US capitalistic evolution of last fifty years and inspect the way the distribution of income between wages and profits can determine the rate of innovative activity and then further attainments in productivity. I consider major features of the US post-1972 economy like the progressive worsening of the functional distribution of income at the expense of the labour share and, on the other hand, the slower growth in R&D expenditure. I advance the idea that the continuous shrinkage of the labour share may have resulted in a smaller incentive to invest in R&D activity, entailing the evident decline in productivity performances that marks the US Secular Stagnation. The model in this chapter is none the less incomplete, since it does not deal with growth question but analyzes economic systems approaching and gravitating around a stationary state.

In the third chapter, "*Secular Stagnation and innovation dynamics: An agent-based SFC model. Part II*", I extend the argument started with the second chapter. In other words, I develop an agent-based, stock-flow consistent model to analyze the nexus between income distribution and innovative search in determining economic growth. The model is still able to match a wide spectrum of stylized facts well in tune with the micro- and macroeconomic literature, such as endogenous and self-sustaining economic growth.

For what concerns to distributive policies and their relationship with innovation rates, theoretical policy implications do not change significantly from the second essay. However, they do change with respect to the role exerted by the interest rate. What I grasp as a side result is that the rate of interest has a non-linear and small effect upon innovation efforts and on the overall level of economic activity. More precisely, the very non-linearity in the R&D pattern comes out of the contrasting movement between the revenue and the cost components the R&D investment schedule is made of. On the one hand, entrepreneurs increase consumption in absolute terms because more profits accrue to their pockets and their need to innovate rises;

but on the other hand, they feel less afraid of the competitive pressure and reach a normal profit rate more easily, so their necessity to seek for labour-saving techniques looks reduced.
Last part of the paper does also involve econometrics. I want indeed to test some predictions from my model to the empirical ground. In so doing, I gather a panel of US manufacturing industries with data on total R&D expenditures, hourly wage rates, productivity levels and values of shipments from 1958 to 2011. I carry out a twofold empirical analysis. First, I try to find empirical evidence of a positive and long-period linkage between R&D spending and its revenue and cost components. The latter are, respectively, shipments and (productivity-adjusted) wages. I figure out that my series of interest are indeed cointegrated, i.e. there exists a long-run stochastic trend that joins them. I am then able to detect positive and long-lasting evidences, confirming the predictions of our ACE model. The robustness of the results are assessed through the different econometric procedures usually applied to datasets with both large N and large T.
Second, I test the existence of a long-run relationship between R&D investments and the effective federal funds rate, on the one hand, and with the bank prime loan rate, on the other hand. I get the interesting result that no long-period well-established linkage exists between innovative effort and the interest rate, whatever measure I adopt for the latter. This result means that any estimated regression of the former on the latter would provide us with spurious coefficients. Still, it does not conflict with my expectations.

All in all, the dissertation highlights the role played by the complex connections between income distribution and innovation in burdening the dynamics of productivity in the United States. However, I have to say that proposed rationales for Secular Stagnation are not the only valid explanations: non-technological motives, lower top marginal tax rates, increased low-skill immigration, rising trade with China and with other low-cost manufacturing countries or the rise of superstar firms are equally important. Eichengreen's Rorschach test means exactly that: paraphrasing Richard Goodwin's belief about economics, Secular Stagnation is "so impossible complex as to defy any completely satisfactory analysis". I promise to deal with these further issues in my future research.

Enjoy the reading!

Chapter 1

Does the Secular Stagnation Hypothesis Match with Data? Evidence from USA

1.1 Introduction

The concept of Secular Stagnation has been introduced in the economic field by Hansen (1939) to describe the somber situation in which the US economy fell after the Great Depression in 1929. The author looked at the high unemployment as the principal problem for Americans and the expression of Secular Stagnation stood for "sick recoveries which die in their infancy and depressions which feed on themselves and leave a hard and seemingly immovable core of unemployment" (Hansen, 1939, p. 4). Since then, the debate around Secular Stagnation tends to be raised whenever a strong recession takes place (Pagano and Sbracia, 2014), albeit the doctrine of Secular Stagnation had generally exited the economic discourse since the late Fifties, and almost disappeared from the macroeconomic research agenda (Backhouse and Boianovsky, 2016). To date, Summers (2014a) re-evoked this expression to depict a circumstance in which changes in the economic fundamentals, after the Great Recession of 2007, might have caused a significant shift in the natural balance between savings and investments, lowering the equilibrium natural interest rate associated with full employment towards negative values. The outcome is a state of affairs in which the achievement of adequate growth, capacity utilisation and financial stability appears increasingly difficult (Summers, 2014a,b, 2015, 2018).

Many economists have dealt with this phenomenon since then, each of them underlining a peculiar aspect. In the present chapter, I decide to take a historical perspective in order to see which characteristics associated with Secular Stagnation are found in the data. In particular, I focus my study on US macroeconomic data about real GDP per capita, potential output, productivity measures and population since 1870, when possible. This very simple setting allows me to prove that the slow growth in real GDP per capita as in more recent times should not be interpreted as an evidence of Secular Stagnation. Rather, it represents the return back to the average growth rates performed before the Golden Age period 1950-1972. It is apt to talk about Secular Stagnation in terms of labour and multifactor productivity growth, since their decline is greater than any previous shortfall. My findings cast some doubt on Summers' hypothesis of negative natural rates, which suffers from theoretical inconsistencies as suggested by Di Bucchianico (2020) and Palley (2019). In contrast, a careful analysis of data offers some evidence supporting to Gordon (2014, 2015) and Hein (2015, 2016)'s Secular Stagnation hypotheses, among others. Moreover, this evidence shows that the use of the term "Secular Stagnation" in the literature is somewhat *misleading*, since it should concern to a longer time span, possibly involving *more extended long runs*. Finally, I trace out a complementarity or even convergence to what policy-makers should do to get away from this trap, the great heterogeneity in the perspectives adopted notwithstanding.

The paper is organised as follows: Section II presents my empirical findings that help give a proper definition for Secular Stagnation; Section III looks at Secular Stagnation through the lens of the Great Recession, as in Summers (2014a,b) and Eggertsson et al. (2019); Section IV pins down to the supply-side determinants of the productivity slowdown in growth while Section V deals with its demand-side causes. Both Section IV and V frame Secular Stagnation in terms of productivity growth. Section VI provides policy implications while the Section concludes and paves the floor to the next chapters.

1.2 Secular Stagnation since late nineteenth century

The concept of Secular Stagnation, as above, has been introduced in the economic field by Hansen (1939) to describe the somber situation in which the US economy fell after the Great Depression in 1929. The author looked at the high unemployment as the principal problem for Americans. Hansen believed that the events occurred in the first quarter of the twentieth century constituted a profound structural change not smaller than the one provoked by the

Industrial Revolution.[1] In this frame, he stressed three main points as the *causae causantes* of this stagnating growth process: a drastic decline in the rate of population growth, changes in the character of technological innovations and the availability of new territories. On the one hand, population growth, an increasing speed of technological innovation and colonial expansion in the past, with the conquest of new territories, the appropriation of the natural resources and the creation of new markets, fueled industrial development in many Western countries. On the other hand, population decline, a slowing down in the rate of technological innovation and the lack of new territories had a negative impact on the economies. Policy-makers should then have prompted a strong public investment in human and natural resources along with a gradual lowering of tax rates in order to soothe households and to strengthen their consumption expenditures. Of course, Hansen wrote the paper before World War II, the Golden Age growth and all the subsequent events the humankind witnessed so far, the evolution undergone by the role of governments in most economic systems included. Moreover, Hansen had claimed since the Sixties that his notion of Secular Stagnation was another name for Keynesian underemployment equilibrium, being both problems about the difficulty from matching savings to investments (Backhouse and Boianovsky, 2016). Nevertheless such changes do not imply that Secular Stagnation is just an old-fashioned and implausible ghost (Summers, 2015).

Since several economists have analysed the phenomenon through a variety of perspectives once Hansen (1939) first used the concept, it is hard to find evidence of Secular Stagnation by simply looking at a unique macroeconomic indicator. For what concerns to my analysis, I here define Secular Stagnation as the tendency to the long-term slowdown in the growth rates of labour and total factor productivities, along with a decreasing potential output growth and a return to pre-1950 average growth rates of actual GDP, which starts in the early Seventies and reaches the trough with the Great Recession in 2007.[2] *Semantics* matters: the term *stagnation* implies the idleness of the economic activity relative to some historical benchmark, usually the preceding years; however, since I consider a very long time horizon – more than a century – the word *secular* does not imply a *single* long run, but *more long runs*. This is a crucial

[1] "He saw the concept as rooted in J. S. Mill's notion of the stationary state, suggesting that the term "mature economy" described Mill's formulation of the stationary state as a low-investment but high-consumption economy. However, unlike Mill's stationary state, Hansen's secular stagnation featured *chronic unemployment*" (Backhouse and Boianovsky, 2016, p. 951; italics in original).

[2] Economists define *potential output* as what can be produced if the economy were operating at maximum sustainable employment (Okun, 1963). The concept itself, and the way it is computed, is very debated in the literature. Since I do not enter such a matter, I refer to EU Commission official measure; details in the Appendix.

point within the debate around Secular Stagnation. Economic historians, indeed, differentiate between their *long run* concept and the *long run* usually adopted by economists: when the analysis concerns to fifty years, for instance, it corresponds to a *short period* perspective for economic historians and a *long run* one for economists; a study should involve a century at least to be considered as long-run point of view by economic historians.

Economists tend to raise this debate whenever a strong recession takes place. Moreover, a historical perspective suggests that current performance in GDP per capita growth rates are not different from what the capitalistic system experienced in the nineteenth century or in the first half of the twentieth. However, several studies disregard the pattern followed by productivity growth in last 150 years and therefore, looking at Secular Stagnation mostly as a productivity issue, I believe that the following questions deserve attention: is Secular Stagnation a fact? Is the slow growth since the early 1970s just a return to average performances similar to what happened to real GDP per capita after the exception of the Golden Age, or has it got any special feature?

In order to answer such a complex question, it is necessary to clarify why I prefer focusing on labour and multifactor productivity growth and why not solely on real GDP per capita. Neoclassical wisdom in particular believes that labour productivity and TFP are both the key drivers of economic growth, changes in living standards and as a measure of international competitiveness and efficiency. By contrast, real GDP per capita is more volatile and very pro-cyclical, making its analysis less reliable. Such a measure is not indeed very different from labour productivity measured as per person employed. However, the growth rate in GDP per capita can be broken down into the sum of two components, i.e. the growth rate of GDP per hours worked, on the one hand, and the growth of labour utilisation on the other hand, that is hours worked per capita. GDP per capita is a reliable measure for productivity only to the extent that the strong assumption of constant labour utilisation results verified.
I prefer restricting the analysis to the United States using data from 1870 onward, whenever available. The reason is twofold: firstly, the literature on Secular Stagnation focuses mainly on the American economy and, secondly, the USA are one of the remaining superpowers and the economic science has identified them as the world's technology frontier since the early twentieth century (Pagano and Sbracia, 2014). Secular Stagnation began in the early Seventies, which were characterized by a slowing down of productivity growth. In this framework, the

slight increase in productivity growth rates which characterized the Nineties was determined by a short-run economic cycle which did not affect the long-run negative trend, but only served to conceal it.
It is worth dividing the analysis of the results in two parts. The first part presents productivity statistics in Tabs. 1.1 and 1.2, as well as in Figs. 1.1 to 1.4. The second part focuses on output and population statistics, as reported on Tab. 1.3 and graphed in Figs. 1.5 and 1.6.[3]

The slowdown in growth performances during the post-Golden Age period did not simply represent a return back to pre-Golden Age periods. What makes the Secular Stagnation hypothesis consistent with data is the strong negative trend followed by productivity. For simplicity, I shall start by looking at the labour productivity pattern, with the aid of Tab. 1.1, Figs. 1.1 and 1.2. The time trend has a negative sign and is statistically significant, although small in absolute value, from 1889 through 2017. It means that there was a slow and steady decline in labour productivity growth over the period of interest. However, Figs. 1.1 and 1.2 show that such decline starts with the end of the Golden Age. If we perform separate regressions using data from 1889 through 1940, and from 1950 to 2017, respectively, we find that the growth in labour productivity is *trendless* and slightly above 2% before World War II (1889-1940), while a consitently negative trend characterizes the second half of the XX^{th} century. Despite the great volatility in actual growth rates, the steady decline in labour productivity begins at the end of the Golden Age. Time only strengthens this trend reversion, as the structural break in 1971 confirms. The rate of growth of labour productivity exhibits a timid recovery in the Nineties with another structural break in 1993, before starting a new and long-lasting collapse in the aftermath of the 2007 crisis.

For what concerns to the multifactor productivity growth, I compare different data, in the line of Gordon (2010). Fig. 1.3 plots my estimates on total factor productivity based on the accounting exercise which does not consider the composition adjustments concerning to the aggregation of different components of capital and labour inputs.[4] These preliminary estimates refer to the period 1889 – 2018. When it comes to the Post-Word War II period,

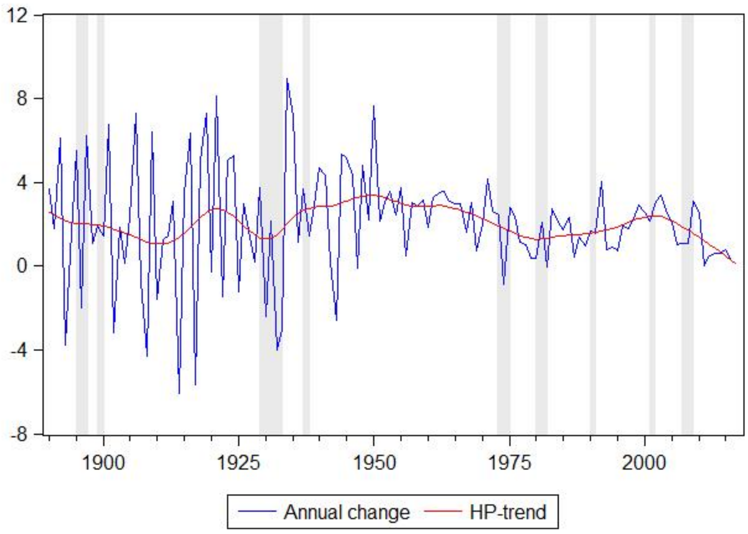
[3]Since data contains both the trend and the cyclical components, I smooth the time series with the Hodrick-Prescott filter in order to capture the trend component and to focus the study on it. Nevertheless, I must recognize that thinking the cyclical and the trend components as *additive* is a very simplifying hypothesis.

[4]In other words, I do not take into account the differences between ICT and non-ICT capital, and between skilled and unskilled workers. I instead computed TFP as the Solow residual from a standard Cobb-Douglas aggregate production function. Further details in the Appendix.

Time	Average growth rates		
1889 – 1920	0.017		
1920 – 1950	0.025		
1950 – 1972	0.028		
1972 – 1996	0.016		
1996 – 2007	0.022		
2007 – 2018	0.010		
Trends and Bai-Perron test for labour productivity			
Time	Trend $\hat{\beta}$	Sequential L+1 breaks vs. L	Sequential test all subsets
1889 – 2018	−0.004**	1916, 1935, 1993	1916, 1935, 1971, 1992
1889 – 1940	0.007		
1950 – 2018	−0.029***	1971, 1993, 2008	1973, 1983, 1993, 2008

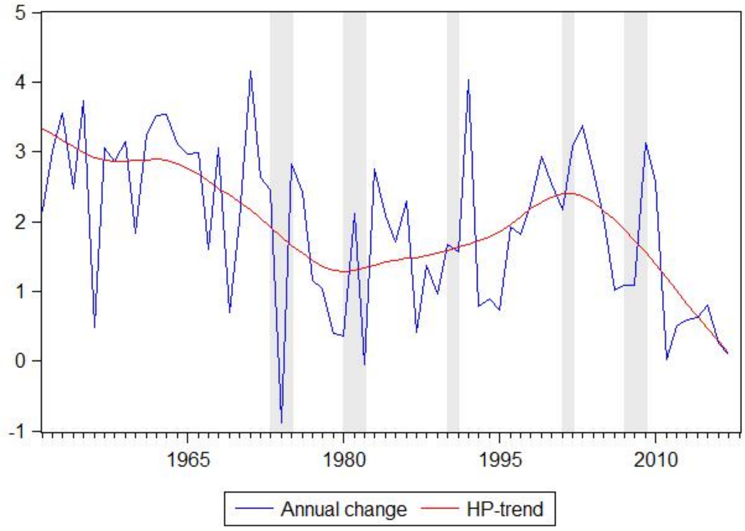
Note: trend $\hat{\beta}$s refer as to a simple OLS regression $y_t = \alpha + \beta trend + u_t$, which traces the evolution over time of our variable of interest. To ascertain information about the different specification of the Bai-Perron test, see Bai (1997) and Bai and Perron (1998). Values are computed over HP-filter trend components of individual time series. Star significance: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 1.1. Statistics for labour productivity, 1889 – 2018



Note: labour productivity is measured as real GDP per hours worked; shaded areas refer to major crises. Source: author's own calculations on Kendrick (1961) and Penn World Table 9.1 data.

Figure 1.1. Labour productivity in the USA, 1889 – 2018



Note: labour productivity is measured as real GDP per hours worked; shaded areas refer to major crises. Source: author's own calculations on Penn World Table 9.1 data.

Figure 1.2. Labour productivity in the USA, 1950 – 2018

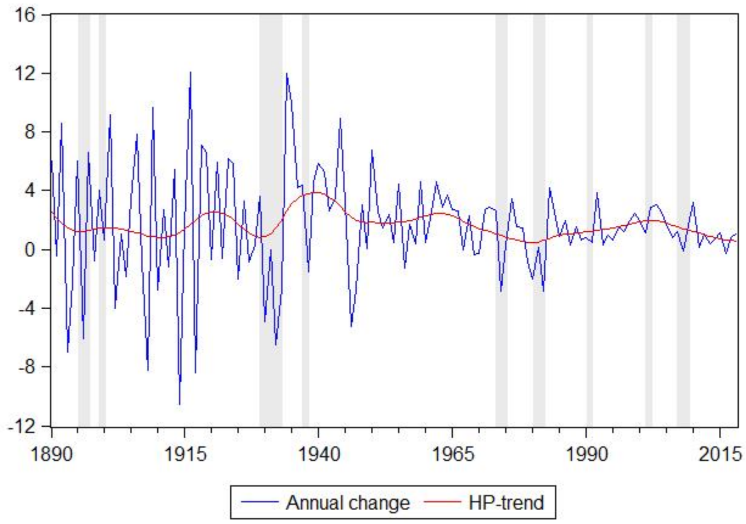
however, I prefer using adjusted estimates provided by the Bureau of Labor Statistics, which allow for a more detailed analysis.

Considering non-adjusted estimates, the results tend to confirm what Gordon (2010) obtained. In particular, we see that the period 1920-1950 benefits from the highest growth in TFP with a rate strictly above 2%, as the result of fifty years of continuous growth. In contrast, none of the following years exhibits a growth rate of productivity exceeding 2%. Moreover, structural breaks between 1968 and 1970 lead to further progressively smaller rates of productivity growth. As for the previous measures, the end of the second millennium and the onset of the third represent a temporary relaunch – the growth is 1.8% on average –, but then the long-term decline reaches the bottom in the following years. The pattern is confirmed also by the structural breaks occurred in 1970, 1992 and 2009, respectively. The official BLS measures are in lines with my preliminary results, with the post-Golden Age itself representing a structural break followed by a plunge in TFP (Tab. 1.2 and Fig. 1.4). In particular, TFP grows 1.7% on average during 1950-1972, then it collapses to one-third of that value in 1972-96. The growth rate doubles in subsequent years (1.23%) but reaches the bottom in the post-2007 decade, that is 0.53% only.

Time	Average growth rates		
	Non-adjusted estimates	BLS adjusted estimates	
1889 – 1920	0.015		
1920 – 1950	0.024		
1950 – 1972	0.019	0.018	
1972 – 1996	0.009	0.006	
1996 – 2007	0.018	0.012	
2007 – 2018	0.009	0.005	
Trends and Bai-Perron test for non-adjusted TFP			
Time	Trend $\hat{\beta}$	Sequential L+1 breaks vs. L	Sequential test all subsets
1889 – 2018	−0.005***	1914, 1933, 1968, 1990	1914, 1933, 1968, 1991
1889 – 1940	0.029***	1916, 1925, 1934	1916, 1925, 1934
1950 – 2018	−0.013***	1970, 1992, 2009	1960, 1970, 1992
Trends and Bai-Perron test for BLS TFP			
Time	Trend $\hat{\beta}$	Sequential L+1 breaks vs. L	Sequential test all subsets
1948 – 2018	−0.021***	1972, 1994, 2008	1972, 1984, 1994

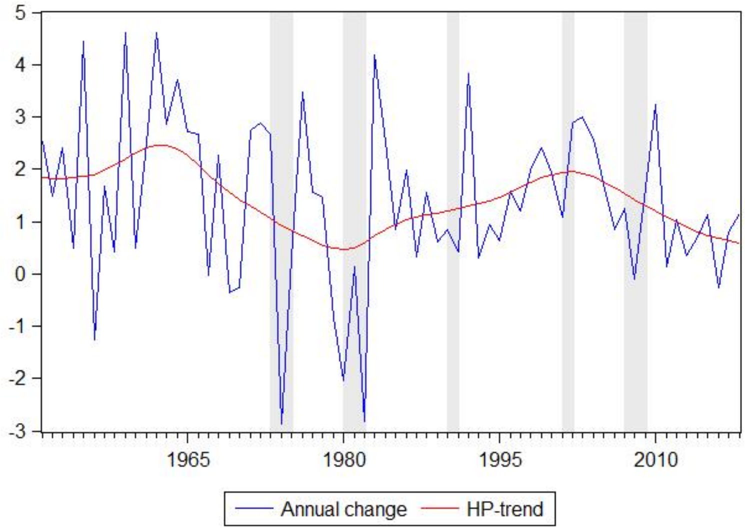
Note: trend $\hat{\beta}$s refer as to a simple OLS regression $y_t = \alpha + \beta trend + u_t$, which traces the evolution over time of our variable of interest. To ascertain information about the different specification of the Bai (1997) and Bai and Perron (1998). Values are computed over HP-filter trend components of individual time series. Star significance: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 1.2. Statistics for multifactor productivity, 1889 – 2018



Note: TFP refers to Private Nonfarm Business Sector; shaded areas refer to major crises. Source: author's own calculations on Kendrick (1961) and Bureau of Labor Statistics data.

Figure 1.3. Total factor productivity in the USA, 1889 – 2018



Note: TFP refers to Private Nonfarm Business Sector; shaded areas refer to major crises. Source: author's own calculations on Bureau of Labor Statistics data.

Figure 1.4. Total factor productivity in the USA, 1950 – 2018

The second slot concerns to some data about the growth rates in real GDP per capita, potential output and population. We see from Tab. 1.3 and Fig. 1.5 as the actual growth path in real GDP per capita is almost trendless since the late nineteenth century. In addition to this, we can interpret its hump and subsequent decrease after the Golden Age period as the return back its average growth before the years represented by the Golden Age of capitalism; in this respect, Golden Age years were somehow peculiar, characterized by a more sustained growth of the social product if compared to either preceding periods or subsequent decades.[5] Concerning potential output, the lack of historical data does enable me to say neither that its continuous decline in growth represents a return back to average pre-Golden Age performances nor that it is a new feature. Hence, it cannot be a support for my claim as well as for GDP per capita. I limit myself to back up a significant decreasing pattern in its growth rates.

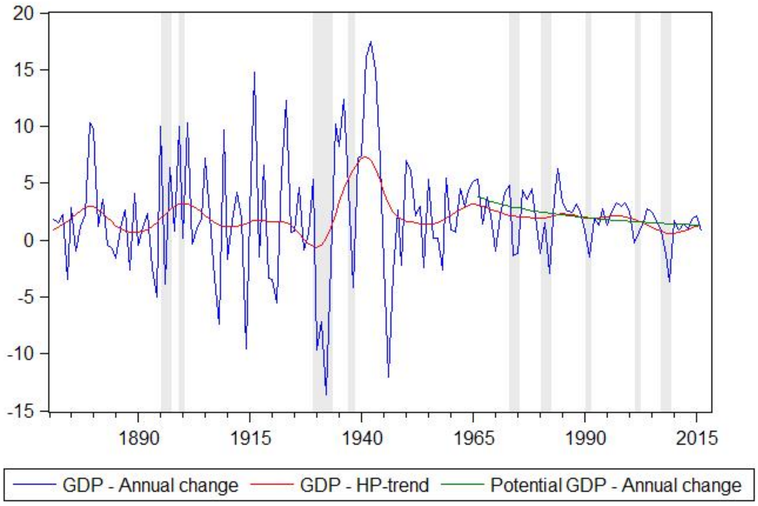
To complete the second slot of statistics, we shall have a glance on some demographic dynamics. Hansen (1939) first, Gordon (2014, 2015) and Summers (2014a,b, 2015) later, believe that declines in US population growth are one of the major determinants for Secular Stagnation. Data on Tab. 1.3 and the picture drawn in Fig. 1.6 show a plunge in population growth from 1870 until the end of World War II. The temporary leap in the growth rate of population

[5] A full and exhaustive analysis of the rationales behind the Golden Age of capitalism is Armstrong et al. (1991).

Time	Average growth rates		
	Real per capita GDP	Potential output	Population
1870 – 1920	0.018		0.021
1920 – 1950	0.028		0.012
1950 – 1972	0.022	0.034	0.015
1972 – 1996	0.021	0.023	0.010
1996 – 2007	0.016	0.016	0.011
2007 – 2016	0.0086	0.014	0.008
Trends for real per capita GDP			
Time	Trend $\hat{\beta}$		
1870 – 2016	−0.001		
Trends and Bai-Perron test for potential output			
Time	Trend $\hat{\beta}$	Sequential L+1 breaks vs. L	Sequential test all subsets
1966 – 2016	−0.045***	1974, 2006	1974,1981,2006
Trends and Bai-Perron test for population			
Time	Trend $\hat{\beta}$	Sequential L+1 breaks vs. L	Sequential test all subsets
1870 – 2016	−0.01***	1925, 1946, 1967, 1988	1916, 1946, 1967, 1988
1870 – 1940	−0.024***	1890, 1915, 1929	1890, 1915, 1929
1950 – 2016	−0.013***	1964, 1979, 1989	1964, 1979, 1989

Note: trend $\hat{\beta}$s refer as to a simple OLS regression $y_t = \alpha + \beta trend + u_t$, which traces the evolution over time of our variable of interest. To ascertain information about the different specification of the Bai-Perron test, see Bai (1997) and Bai and Perron (1998). Values are computed over HP-filter trend components of individual time series. Star significance: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 1.3. Statistics for real per capita GDP, potential output and population, 1870 – 2016

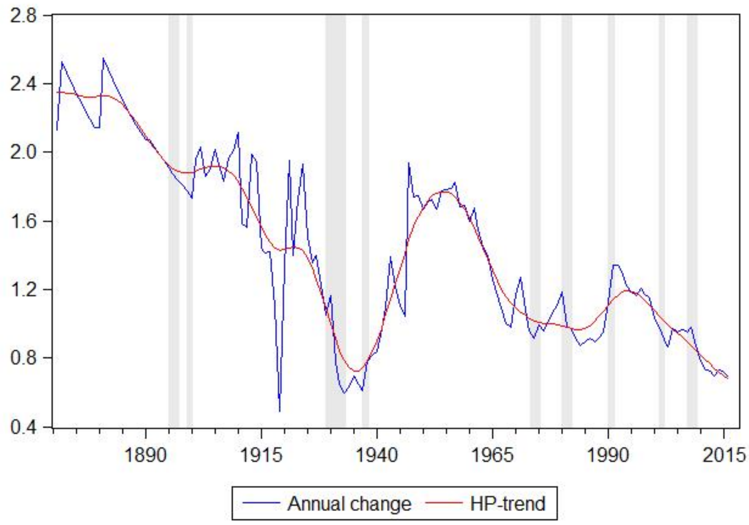


Note: data refer to the whole economy; shaded areas refer to major crises. Source: author's own calculations on Macrohistory Lab Bonn and Ameco data.

Figure 1.5. Real GDP per capita and potential output in the USA, 1870 – 2016

during the Golden Age – the so-called *baby-boom generation*– was totally offset by the clear-cut decrease in last decades. Some could ask how a trendless growth in GDP per capita can coexist with decreasing productivity growth. The decomposition presented in (1.1) sheds light on that issue. On the left-hand side, we have the growth rate of GDP per capita; on the right-hand side, we see the former as result of changes in labour productivity and per capita hours worked. The increasing number of working women and the entrance of the baby boomers into the labour market from 1965 through 1990 pushed per capita hours upward, but the same years saw a decrease in labour productivity. Ramey (2020) provides robustness to my results above. For what concerns to per capita hours worked, she notices as they rose from 1975 to 2020, owing to the entry of baby boomers into the labour force and rising female participation rates. Moreover, although the employment-population ratio exhibits a decline since the onset of the third millennium because of baby boomers' aging, that series displays a recovery since 2010, though not to the levels of the Nineties. The upward trend in the employment-population ratio since the 1930s looks still in place.

$$\Delta ln\left(\frac{GDP}{Population}\right) = \Delta ln\left(\frac{GDP}{Hours}\right) + \Delta ln\left(\frac{Hours}{Population}\right) \tag{1.1}$$



Note: shaded areas refer to major crises. Source: author's own calculations on Macrohistory Lab Bonn data.

Figure 1.6. Population in the USA, 1870 – 2016

	1959 – 2006	1959 – 1973	1973 – 1995	1995 – 2000	2000 – 2006
Private output	0.036	0.042	0.031	0.048	0.030
Hours worked	0.014	0.014	0.016	0.021	0.005
Average labour productivity	0.021	0.028	0.015	0.027	0.003
Contribution of capital deepening	0.011	0.014	0.009	0.015	0.013
Information technology	0.004	0.002	0.004	0.010	0.006
Non-information technology	0.007	0.012	0.005	0.005	0.007
Contribution of labour quality	0.003	0.003	0.003	0.002	0.003
Total factor productivity	0.008	0.011	0.004	0.001	0.009
Information technology	0.003	0.001	0.003	0.006	0.004
Non-information technology	0.005	0.011	0.001	0.004	0.005
Share attributed to information technology	0.003	0.001	0.004	0.006	0.004

Source: Jorgenson et al. (2008).

Table 1.4. Source of output and productivity growth in United States, 1959 – 2006

It is worth spending a few words on the temporary recovery which marked the second half of the 1990s and lasted until early 2000s.[6] Neoclassical literature widely recognizes that such a productivity upsurge is due to the expansion and diffusion of information technologies, from computers to software and communications equipment. On the one hand, we can divide TFP between growth in the ICT sector and growth in the non-ICT economy. On the other hand, ICT benefits can be traced out in the way capital deepening consists of more intensive application of ICT capital (Jorgenson et al., 2008). Before 1995 the contribution of ICTs to output and labour productivity growth is small. In particular, labour productivity grows 2.14 percent on average during 1959-2006, with 55% of such growth attributable to factors other than information technologies. On the contrary, in the Nineties important developments in information technologies lead to a substantial increase in the share of productivity growth attributed to the ICT sector, which soars from 43% in the period 1973-95 to 59% between 1995 and 2000. Nevertheless, the beginning of the XXI^{st} century witnesses a decline in the contribution of ICT in productivity growth: the average labour productivity growth is almost constant but productivity growth is attributable in the greater part to capital deepening and TFP than to information technologies. This evidence does not render the contribution of ICT capital to growth negligible anyway.

To recap, since the early Seventies, the most advanced economy has experienced a slowdown in both labour and multifactor productivity growth. Compared to a century ago, the definition of Secular Stagnation does not imply a *simple* or *single* long run, but one more extended long run or even *more long runs*. This evidence represents a crucial point. Such a

[6] Check Tab. 1.4, which refers as to Jorgenson et al. (2008). The reader will notice that my computations are somewhat different from Tab. 1.4, although they exhibit the same qualitative pattern. The reason lies in the different methods implemented to compute TFP growth, especially in the separation between skilled and unskilled workers, ICT and non-ICT capital, and the filter adopted to clean the time series from their cyclical components.

definition of Secular Stagnation has two implications. Firstly, the years analyzed by Hansen (1939) did not seem periods characterized by Secular Stagnation. The growth in GDP per capita, labour productivity and TFP were in fact *constant* or slightly increasing in the case of total factor productivity. Although population growth has indeed been slowing down, that would soon have changed with the baby-boom generation. Pagano and Sbracia (2014) and Ramey (2020) support my claim. The assertion that the progress in electricity and in the car industry were over well before the late 1930s is indeed false: the electrification of cities took place precisely after World War I. Secondly, although the US car industry did experience a crisis, it was not widespread. Such industry spread on the contrary to other countries. Thirdly, the possibility that television broadcasting would have begun to replace radio in nearly all Western countries, whose process started during the early Thirties truly. In short, Hansen underestimated the potential of what technologies were already known in his time. The reason of this mis-interpretation lies in the fact that the arrival of a revolutionary technology may be associated with negative events such as stock market crashes or productivity slowdowns, due to waves of reorganization (Ramey, 2020). Because of these counter-intuitive effects, technological revolutions might not be grasped immediately. These effects probably led Hansen not to recognize that the period he characterized by Secular Stagnation was actually "the most innovative decade of the 20^{th} Century" (Ramey, 2020, p. 8), whereas the huge unemployment he underscored was due to a heavy but *cyclical* crisis. This last statement explains why the long-run decrease in productivity growth comes to a halt in the late 1990s. The development of information technology emerges as the driving force behind the growth in labour and multifactor productivity in the mid-1990s, while they lose ground after 2000 to the benefit of capital deepening and TFP outside the ICT sector (Jorgenson et al., 2008).[7]

These findings raise a further question: how does our definition of Secular Stagnation contribute to the debate on the topic? The question discussed below is how the Secular Stagnation hypothesis and the related policy implications developed in recent times meet the qualitative and quantitative evidence presented above. I begin with the natural rate view as promoted by Summers (2014a,b, 2015) and Eggertsson et al. (2019), which however considers

[7] The careful reader will point at this point that the concept of TFP relies on, at least in its original formulation, the notion of *exogenous* technical progress. She would then ask if we can conceive technical progress as exogenous anyway. I reply that no, technical change is not exogenous at all and there is a lot of literature on that (Dosi and Nelson, 2010). The very concept of TFP is controversial and I refer to Shaikh (1974) for further details. I would like to remark that I employ TFP as a descriptive tool, for the reason explained above: it is hard to detect evidence of Secular Stagnation by simply looking at a unique macroeconomic indicator. I have to rely on multiple *instruments*, imperfect and much-disputed as they might be.

Secular Stagnation as a trap started with the meltdown in 2007. More coherent approaches on the productivity slowdown in growth follow.

1.3 Secular Stagnation through the lens of the Great Recession

The stream of literature considering the natural interest rate as the key factor for understanding Secular Stagnation is quite homogeneous and I am going to analyze Summers (2014a,b, 2015) and Eggertsson et al. (2019) as major contributions to the topic. In what follows, the natural rate of interest is the Wicksellian one, defined as the rate "at which *the demand for loan capital and the supply of savings* exactly agree, and which more or less corresponds to the expected yield on the newly created capital" (Wicksell and Claseen, 1935, p. 193; italics in original). This framework focuses on persistent gaps between actual and potential growth in GDP. During his famous speech at the NABE Policy Conference in 2013, Larry Summers suggested that changes in the economic fundamentals, as consequences of the Great Recession, might have caused a significant shift in the natural balance between savings and investments, lowering the equilibrium natural rate associated with full employment towards negative values, and triggering a process in which the achievement of adequate growth, capacity utilisation and financial stability would be, at best, hard (Summers, 2014b).[8]

Why did the natural rate become negative? Summers (2014b) traces out different causes through the loanable funds theory and the changes which would have occurred either on the demand or on the supply sides. On the *demand side*, three main factors may have shifted the demand schedule for savings – the investment curve – to the left. Firstly, the deleveraging process which followed the strong leverage antecedent to the financial crisis of 2007. Secondly, a structural change in the economic system due to the progressive rise of technological companies like Google, Amazon or Facebook. These multinationals all achieved very high market values but they need not much capital investment, especially if compared to others. Thirdly, the fall in the growth rate of population reduced the demand for capital stock and housing finance, while at the same time it increased the supply of funds through capital funded pension systems.

On the *supply side*, along with the adverse effects associated with population dynamics, Summers points out that since the Eighties we are witnessing a progressive rise in top incomes and wealth shares at the expense of bottom incomes in nearly all countries, leading to a higher

[8] The idea of negative Wicksellian natural rate is not new in economics: Klein (1947) already dreaded the possibility in a discussion with Pigou about Hansen's work. More on that in Backhouse and Boianovsky (2016).

average propensity to save in the economy.[9] Finally, rising retained earnings and tighter regulations for financial firms shifted to the right the supply curve for loanable funds. The upshot may be a *negative* equilibrium natural rate of interest. The presence of a negative natural rate renders the Central Bank's monetary policy ineffective, which explains the Zero Lower Bound on nominal rates and low inflation rates experienced nowadays.[10]

Summers's view is not exempt from criticism, however. Di Bucchianico (2020) and Palley (2019) have challenged the theoretical admissibility of a (negative) natural rate within the neoclassical framework. We can appreciate the former criticism through a simple economy in which a single good is produced by means of capital and labour. For simplicity, I set inter-temporal optimizing behaviour aside and assume entrepreneurs maximize their profits. According to Summers, and regardless of any Zero Lower Bound influence, the entrepreneurs adopt very high capital-labour ratio techniques that let economy reach a equilibrium position in correspondence of a negative marginal product for capital. Di Bucchianico (2020) questions the formal existence of a negative marginal product of capital through the adoption of an aggregate production function of the type:

$$y = Ak^{\alpha} \tag{1.2}$$

$$f_K = A\alpha k^{\alpha-1} \tag{1.3}$$

in which y is output per unit of labour, A the Solow residual, α the capital share in output, k the capital-labour ratio and f_K the marginal productivity of capital. We notice that as long as the capital-labour ratio increases, the marginal product of capital keeps decreasing without approaching any negative value.[11] The economic intuition behind that and within the neoclas-

[9] Piketty (2014, 2015) raised the debate on the increasing income and wealth inequalities since 1980s, for which he was able to collect a very large historical dataset on national incomes and wealth, covering three centuries across several countries. Fig. 1.7 and 1.8 track their evolution in the USA over time. The analysis reported to a positive relation between wealth inequality and the difference between r and g, in which the former is the rate of return on capital while the latter is the economy's growth rate. In other words, "a higher gap between r and g works as an amplifier mechanism for wealth inequality" (Piketty, 2015, p. 49). In contrast, the same term $r - g$ is not a helpful tool to discuss about the rising inequality of labour incomes: I will come back to this issue as soon as I deal with Gordon's Secular Stagnation.

[10] Summers' analysis helps understand why real rates and actual output dropped in recent times, but not why potential output fell. He advocates on the theory of hysteresis and theorizes an "Inverse Say's Law", according to which lack of demand creates lack of supply. Actually, this expression might be misleading. Basically, the principle of effective demand is at work.

[11] In this case, the non-existence of a negative rate does depend neither on the functional form of the aggregate production function nor on the lack of capital depreciation.

sical framework is threefold. First, there always exists a positive rate of interest such that the demand for capital per capita is able to employ all the amount of savings supplied. Second, the very idea of a negative rate contradicts the neoclassical principle of profit maximization: why should rational entrepreneurs employ an amount of capital which gives back a negative marginal product? Clearly, they should not, since they can always use capital such that the marginal product would be, at most, null. And third, a negative rate would clash with the product-exhaustion theorem. Di Bucchianico (2020) shows that the equalisation between natural rate and profit rate entails a labour share greater than the net product. Even if a negative rate were plausible, capitalists would still invest in real capital so to get a negative profit rate. In this setting, capital is *abundant* and not *scarce*; at the same time, labour would be *scarce* and not *abundant*. We can demonstrate this statement by re-calling the product-exhaustion theorem, which claims that, since the means of production are rewarded according to their marginal product, they will exhaust net production:

$$Y = f_K \cdot K + f_L \cdot L = \varrho \cdot K + w \cdot L \tag{1.4}$$

In the above, Y is net product, K is aggregate capital stock, L is labour input, ϱ the rate of interest and w the wage rate. The latter is equal, by hypothesis, to the marginal product of labour, f_L. If we admitted the existence of a negative equilibrium rate of interest ϱ, we would have $Y < wL$; in other terms, the labour share in income would exceed the net product of the economy. Setting aside any problem of logical consistency, in this setting capital would be abundant while labour scarce: how can therefore Summers apply this theory to explain a persistently high involuntary unemployment?

Drawing upon Summers' insights, Eggertsson et al. (2019) provides a more general setting for the natural rate hypothesis. They develop an analytic overlapping generation model whose steady-state is characterized by a negative full-employment real interest rate.[12] We can split the model in two main parts: the endowment economy and the production economy. For simplicity I focus on the endowment economy, since the same properties and results hold when they introduce the production side in their model. In particular, the authors suppose that each representative household lives for three periods: when the individual is young, she does not receive income but she borrows from adult consumers; the adults receive an income

[12] The formalization involves a closed economy. Anyway, the results hold in the open economy as well. For details, check Eggertsson et al. (2016).

and they consume part of it, while saving the residual for the old age; finally, the old men receive an income and consume all their endowment.

For my purpose, the most important characteristic of the model is its ability to show how the drop in productivity growth rates since the 1970s triggered the process of Secular Stagnation through negative natural rates. The utility maximization and the equilibrium between the demand for and the supply of loans yield indeed the following equilibrium interest rate:

$$1 + r_t = \frac{1+\beta}{\beta} \frac{(1+g_t)\,D_t}{Y_t^m - D_{t-1}} + \frac{1}{\beta} \frac{Y_{t-1}^o}{Y_t^m - D_{t-1}} \tag{1.5}$$

in which r, β, g, D, Y^m and Y^o represent, respectively, the equilibrium natural rate, the inter-temporal discount factor, the population growth rate, the maximum level of debt a household can borrow, and the incomes of middle-aged and elderly people. For an appropriate combination of the parameters, Secular Stagnation arises as a result of a negative natural rate r.[13] Interestingly, setting the income levels as proportional to productivity A, say $Y_t = A_t \tilde{Y}$, a strong reduction in productivity pushes the natural rate further down. In particular, through the lens of the loanable funds theory on which the model builds upon, the decrease in productivity growth increases the supply of savings, since households face lower expected future incomes. On the other hand, lower productivity makes the borrowing constraint more binding for the young, pushing down their demand for savings.

The results from the endowment economy hold after the production side of the economy is introduced. What the authors discern from the complete model is that monetary policy can be ineffective, and they provide a plausible explanation of why actual monetary policies have been relatively ineffective in many contemporary economies: in order to escape from a Secular Stagnation equilibrium, monetary authorities need to increase the inflation target a lot, while for sufficiently negative real rates, a simple increase in the target does not restore the full employment equilibrium.[14] In contrast, the fiscal policy might be more effective in bringing the economy back to full employment. Overall, their model suggests that fiscal policy might help restore the economic resources to their full-employment levels.

However, Di Bucchianico's criticism holds in this framework too. The introduction of capital

[13]"[I]n contrast to the standard representative agent model, the real interest rate will now, in general, depend on a host of factors in addition to the discount factor: the income profile over the life cycle, the debt limit, and population growth all influence the real interest rate" (Eggertsson et al., 2019, p. 9). For instance, the strong deleveraging post-2007 helps reduce the first term on the right-hand-side of (1.5) as in Summers (2014a,b)

[14]The simulations of the model show that small rises in the inflation target lead to a unique locally determined equilibrium, characterized by Secular Stagnation. In contrast, higher inflation targets give access to two possible locally determined equilibria: as prior, the one with Secular Stagnation and another constituted by full employment of labour.

and monopolistic competition gives rise indeed to an economy in which the return on capital is high enough that it produces returns in excess of investment in the steady state, while the interest rate remains negative (Eggertsson et al., 2019). The discrepancy arises because the rental rate of capital is the ratio between the corresponding marginal productivity and the mark-up, then with positive mark-ups in equilibrium "there can be *social* returns to capital (even net of depreciation) while the rental rate (net of depreciation) and hence the real interest rate is negative" (Eggertsson et al., 2019). But, if the marginal productivity of capital is nonnegative while the natural rate of interest is, the two values cannot coincide and this is not a steady-state solution at all. The steady-state condition requires in fact each agent be indifferent in yielding bonds and physical capital, since they provide the same rate of return. But in this case households would prefer selling their bonds – whose return is negative – and buying real capital – whose return is null. In the end, the true steady state will exhibit a *non-negative* uniform natural rate.[15]

Before conclusion, it is worth spending a few words on a more general critique on the ZLB economics I have just treated. Palley (2019) develops an interesting criticism that runs as follows: even though negative nominal rates were possible, monetary policy may be unable to remedy demand shortage and restore full employment. The reason lies in the investment unresponsiveness to lower interest rates when the returns on non-reproducible assets – fiat money, land, intellectual property right and so on – dominate the returns to investments. Lower interest rates can add further problems if savings rise in response to negative rates. In this way, there might be no natural rate of interest associated to full employment in a neoclassical framework too.

In conclusion, the Secular Stagnation hypothesis through the lens of the Great Recession offers a framework in which Secular Stagnation arises as due to productivity and GDP slowdown in growth. However, the theoretical and crucial assumption on negative natural rates associated with full employment of labour suffers from serious inconsistencies which undermine the solidity of the overall apparatus. The following sections provide two different but more coherent approaches which find supply-side and demand-side long-run causes of

[15] Last point on Di Bucchianico (2020): the author develops his critique on the theoretical admissibility of a negative natural rate within the Euler equation and the Ramsey model frameworks too; in other terms, his results are not circumscribed to the Wicksellian frame as in Summers (2014b). Additionally, he reminds that the existence of a natural rate of interest is doubtful itself, once the results of the Cambridge capital controversy are taken into account. However, I do not consider the implications of that controversy over the Secular Stagnation hypothesis since it is beyond the scope of the present paper. Moreover, it is interesting to note that Klein (1947) already believed that negative natural rates would have been hard to justify in a Ramsey world.

Secular Stagnation which are not based on the cyclical after-effects of the Great Recession.

1.4 Productivity slowdown: supply-side determinants

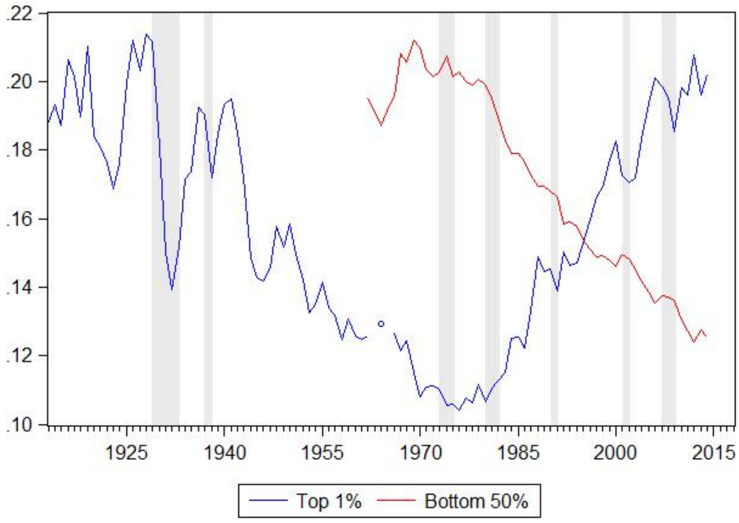
The contributions I examine in this section develop and analyze the supply-side long-run determinants of economic growth and disregard cyclical influences. The authors claim that the strong slowdown in productivity growth and the GDP return back to average pre-Golden Age growth rates were due to some *headwinds*. In this perspective, the low-growth economy becomes the new normal, until some exogenous event boosts supply-side growth.

Gordon (2012) highlights the first important headwind and calls it “the demographic dividend”. It took place in the twenty-five years between 1965 and 1990, which saw an increasing number of women finding employment, together with baby-boom’s children. This influx of workers increased the ratio between working hours and population, while raising real GDP per capita more than labour productivity, by definition. However, we are now experiencing the opposite phenomenon, with the progressive retirement of baby-boomers, diminishing population growth rates and the drop in hours per worker. Whenever the participation rate and hours per worker go down, output per capita grows less than productivity, again by definition (Gordon, 2012). However, Acemoglu and Restrepo (2017) find no negative relation between aging and GDP per capita growth; in contrast, countries undergoing more rapid demographic changes are more likely to adopt new automation technologies as robots, so bringing productivity improvements. In addition to this, Ramey (2020) shows that the civilian employment-population ratio has in fact displayed a recovery since 2010.

The second headwind is extensively outlined by Gordon (2010, 2012, 2015, 2017) and Eichengreen (2015), and it concerns to the revolution started by digital electronics, which ran out of steam, with the electronics facing diminishing returns. A scrupulous analysis of data leads Gordon to establish that, since the Seventies, labour productivity and TFP growth has slackened compared to the years from 1920 to 1972. Furthermore, although we observe a slow climb in productivity and for the benefits enjoyed by many economic systems in the Nineties, production methods changed little throughout the period (Gordon, 2015). Gordon points to three main examples supporting his thesis: office, retailing and business dynamics implemented in short time all the innovations from digitalization, but once the transition was completed, productivity improvements stopped. This view results complementary to what Eichengreen (2015) defines the *range of applicability*. The latter pertains to the number of productive sectors into which new innovations might be integrated. From this perspective, the computer revolution of last fifty years had a relatively smaller impact than preceding innovations like electricity during the Second Industrial Revolution. Computers found applications mainly in the financial sector, as well as in wholesale and retail trade. In addition to this, Eichengreen (2015) underscores the general decline in the relative price of investment goods. The cheapening of personal computers makes the point: carrying out investment projects in ICT commits ever smaller share of GDP, ending up with the decrease in the investment share across the economy, *ceteris paribus*.

Even though the second headwind might provide a plausible explanation for the decline in productivity growth, criticisms come from Crafts (2002), Eichengreen (2015) himself and Ramey (2020). Crafts (2002) carries out a growth accounting exercise to compare the growth contribution of ICT and the related TFP spillovers to previous breakthroughs such as steam engine and electricity. The study suggests that "even before the mid-1990s, ICT had a much bigger impact on growth than steam and at least a similar impact to that of electricity in a similar early phase" (Crafts, 2002, p. 15). Therefore, when adopting a historical perspective it would seem quite ambitious to expect a contribution of greater magnitude and whose effects endured for much longer than those of the ICT revolution.[16] Furthermore Eichengreen (2015) himself advances a thesis running counter to Gordon's, called the *range of adaptation*. It concerns to the wide re-organisation of productive processes necessary to introduce innovations and to trigger greater rates of growth for either GDP and productivity: the bigger the range of adaptation, the longer the time to re-organise the productive system. The range of adaptation hypothesis may shed light, for instance, on why some innovations did beget huge impacts in a short time – steam engine – and others – electricity and internal combustion engine – several years after their discovery. The IT revolution needs time to exhibit all of its potential to fueling economic growth. Stagnation could be just *temporary* and not *secular* any more. Finally and while in agreement with Gordon, (Ramey, 2020, p. 2) argues that "the nature of technological change naturally leads to medium-run variations in productivity growth, and long periods of sluggish growth are a natural outcome of the process that drives technological change". She therefore calls this period as *technological lull*, so to remark its temporary state. However, this is an old argument by David (2007) that explained the low TFP growth of the 1980s and early

[16] I must nonetheless point to as the results obtained by Crafts (2002) should be taken with care, since there are important lacunae in the available information.



Note: shaded areas refer to major crises. Source: author's own calculations on World Inequality Database data.

Figure 1.7. Income inequality in the USA, 1913 – 2014

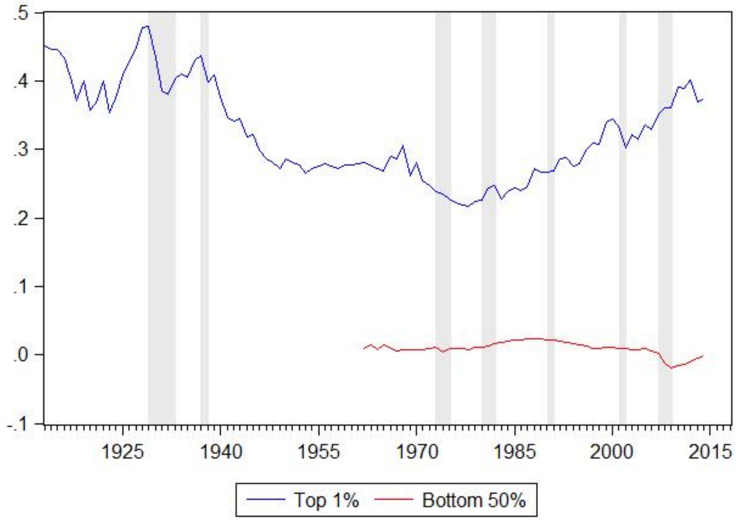
1990s. Whether the same argument still holds today, after almost 40 years of "re-organization", is something to be examined with great care.

The third headwind refers to inequality. Figs. 1.7 and 1.8 show that in the Eighties there is a jump in the share of total income and wealth going to the top 1%, accompanied by the corresponding decrease in the share accrued to the bottom 50%. The shares of income and the wealth going to the top 1% of the population are steadily increasing and these trend show no sign of reversing, while the shares going to percentiles below 50 percent are stagnating.[17] According to Gordon, the increasing inequality has a negative impact on the accumulation of human capital. The problem of education is in fact worrisome at college levels, where students are ever more burdened by the loans they make to pay their college tuition.[18]

To conclude with arguments *à la* Gordon, there are some curious sentences in Gordon (2017) book that seem to contradict the main thesis: while discussing the *Great Leap Forward* of the US labour productivity, occurred in the middle-decades of the 1900s, he argued that the

[17] The analysis of inequality must consider also the path covered by the wage share, hence the functional distribution of income. Since Gordon did not talk about it, I will deal with this topic below, when I analyze some theories that directly cope with it.

[18] Directly quoting (Gordon, 2015, p. 57): "Americans owe $1.2 trillion in college debt, and an increased fraction of the next generation may choose not to complete college as they are priced out of the market for higher education". Note how Piketty (2014, 2015) shares this view, among the others.



Note: shaded areas refer to major crises. Source: author's own calculations on World Inequality Database data.

Figure 1.8. Wealth inequality in the USA, 1913 – 2014

main determinants were the New Deal and strong labour unions, that hoisted real wages. Productivity leaped because higher real wages forced firms to introduce labour-saving techniques. As Nikiforos (2020) notices, this explanation contradicts the neoclassical theory of distribution and the main thesis according to which productivity growth is uniquely supply-side driven as above. Always in the same book, Gordon points out that government deficit spending during WWII brought about an increase in financial assets that allowed a permanent surge of consumption patterns after the war. This point contradicts many neoclassical arguments on the relation between economic growth and public deficit spending.

There is actually another important headwind which the literature did not investigate in connection with Secular Stagnation, but only to the Great Recession. It is the progressive *monopolisation* of knowledge. Pagano (2014) helps explain the ephemeral surge in productivity growth occurred in the Nineties. The author focuses on the *intellectual* monopoly capitalism, i.e. the inclusion of knowledge as the most important capital asset of the firm. From a historical view, we can distinguish two stages: the first is denoted by the *roaring nineties*, during which the World Trade Organization is established. The concomitant creation of a legal monopoly of patents and the cheap availability of new technologies opened new ways for investments and, in that moment, the possibility of privatizing knowledge was a strong incentive for the enterprises to carry out further and further investments. This incentive was crucial to the recovery in productivity growth in the mid-1990s. Nevertheless, this phase of technological developments came to an end at the turn of the XXI^{st} century, as my data confirm. The upshot of this process entails either virtuous or vicious cycles: for individuals owning the intellectual property rights, the financialisation provides incentives to develop new knowledge and then new patents, hence the cycle is virtuous; in contrast, the cycle results vicious for many others, because their lack of intellectual property rights discourages the acquisition of skills and the lack of skills discourages the acquisition of intellectual property rights (Pagano, 2014). Moreover, the current monopolisation of knowledge works at a global level, hence the squeeze of investment outlets is not confined.

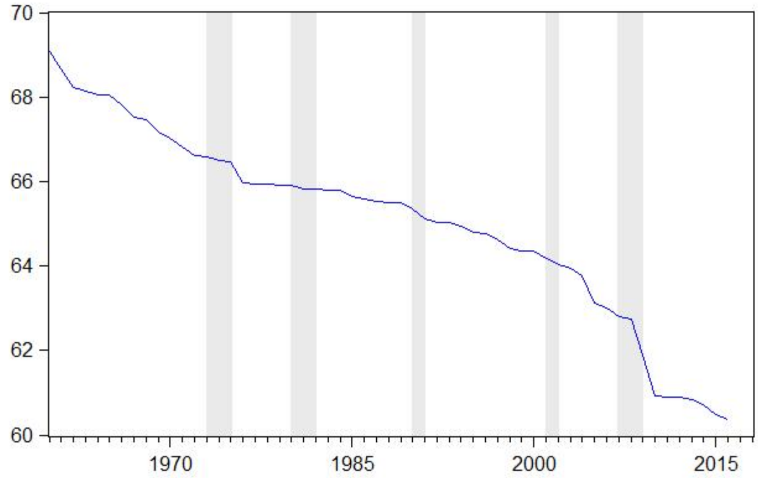
To summarize, this set of contributions around Secular Stagnation provides a coherent supply-side framework for the slowdown in productivity growth and the return to pre-Golden Age GDP per capita growth rates. However, they look at the supply side of the economy only, with the intriguing exception represented by Gordon (2017). The next section considers the other side of the coin, i.e. the demand-side dynamics which weakened productivity and GDP per capita growth. Secular Stagnation is set within the framework of Stagnation Policy.

1.5 Productivity slowdown: demand-side determinants

Every contribution analysed so far, with the possible exception of Summers and Gordon, assumes no influence of aggregate demand in the negative evolution of productivity and GDP per capita growth. Moreover, this literature seems to exclude any influence originating from changes in institutions or power relationships between social classes (Hein, 2016). The weak performances in terms of output and productivity growth in the post-Golden Age era prompted some scholar to suggest that the rise of Secular Stagnation is the outcome of a precise stagnation policy-making.[19] In this framework, it is helpful to analyse the relationship between income distribution, financialisation and accumulation.

During the Golden Age, the full employment of labour was at the centre of most government actions in many Western economies but, since the oil crisis in 1973, there has been

[19]The main references are Hein and Dodig (2014) and Hein (2016); I have to admit as the references of non-neoclassical Secular Stagnation are very few. Additionally, the mentioned authors prefer speaking about Stagnation Policy instead of Secular Stagnation. Engaging in a dispute on proper labeling is beyond my scope; anyway, my focus concerns to Secular Stagnation as a precise *stylized fact*, while Stagnation Policy is about the rationales that led to this fact.



Note: shaded area refer to major crises. Source: author's own calculations on Ameco data.

Figure 1.9. Adjusted wage share in the USA for total economy, 1960 – 2016

a paradigm shift in policymaking towards price stability through restrictive monetary and fiscal policies. The policy shift resulted in reduced shares of income and wealth going to wage-earners and low-income households, as showed in Figs. 1.7 to 1.9. Precisely, the adjusted wage share in Fig. 1.9 keeps decreasing since the late Sixties, when it was 70% almost, to the current minimum 60%. The rise of income inequality and the application of restrictive policies fueled the financialisation of the economy. The rapid structural changes in the post-Golden Age era, marked by a shift to service economies, required more labour flexibility to meet firms needs. In addition to this, corporations' stakeholders started investing more heavily in higher-dividends firms, preferring short-run gains in financial markets to long-run achievements in the real economy. These new goals have been achieved through wage contraction and labour flexibility. However and in order not to jeopardize the consumption capacity for the greatest slice of population, the financialisation of the economy constituted a mean for the *substitution of loans for wages* (Barba and Pivetti, 2009). In this frame, the phenomenon of rising household debt, experienced in many advanced countries, can be viewed as the attempt made by low and middle-income consumers to keep constant or rising their relative standards of consumption, despite the continuous worsening of income distribution in favour of profits and with the approval of political and financial institutions.

The story does not end here: the redistribution of income at the expense of the labour share and the financialisation of the economy lowered the investments in capital stock, through

Time	Gross Fixed Capital Formation	Investment-to-GDP ratio
1960 – 1970	0.050	0.20
1970 – 1980	0.032	0.20
1980 – 1990	0.037	0.20
1990 – 2000	0.046	0.21
2000 – 2007	0.028	0.22
2007 – 2017	0.018	0.20
1960 – 1972	0.046	0.20
1972 – 1996	0.037	0.20
1996 – 2017	0.029	0.21

Note: author's own calculations on Ameco (European Commission) and Macrohistory Lab Bonn data. We use the HP-filter on Gross Fixed Capital Formation growth rates to base our focus on the trend component.

Table 1.5. Statistics on GFCF average growth rates and Investment-to-GDP ratio.

an accelerator mechanism.[20] Tab. 1.5 shows the pattern of gross fixed capital formation and investment-to-GDP ratio. We notice as the two decades after the Sixties point to a sharp decrease in fixed investments, with the trend of average growth rate plummeting from 5% to just over 3.5%. The average growth rate reaches a 4.6% peak in the Nineties. However, the third millennium ushers a steady fall in average growth rate, with it going down to 2.8% between 2000 and 2007 and dropping to 1.8% after the crisis. In contrast, the investment-to-GDP ratio is constant throughout the period. The endogeneity of GDP helps us explain the constancy of the ratio: the debt-led consumption allowed for the compensation of the negative effects on consumption expenditure and income multiplier due to the reduction in the wage share, hence enabling the investment-to-GDP ratio to be invariant, the decline in private investments notwithstanding.

This process gave rise to two different but complementary capitalistic regimes (Hein, 2016). The "debt-led private demand" regime, which established mainly in US and UK, and the "export-led mercantilist" one, as in Germany and China. Further falls in the growth rates of investments in capital stock, as well as income inequality and excessive financialization could then explain the sharp decline in labour productivity and TFP growth, which is not comparable to any previous shortfall. This unsustainable state of affairs would have culminated with the meltdown of 2007.

To sum up, the demand-side view interprets Secular Stagnation as the precise outcome

[20] An usual hypothesis in alternative non-neoclassical growth models is the positive influence on investments of the profit share. Although I do not want to enter theoretical issues the alleged influence arises, it is worth noting that the relation seems either not to hold or to be very weak on the empirical ground (Onaran et al., 2011). Furthermore, other *demand-side* factors look more important as determinants for investments (Girardi and Pariboni, 2020).

of prolonged stagnating demand policies, which fed negatively back on productivity and output growth. Section VI presents the policy implications of the overall analysis I developed so far. Suggestions on how to reverse Secular Stagnation are in the last section as well.

1.6 Any convergence in policy implications?

I have showed that current stagnation in the United States can be explained using different, but not mutually exclusive, theoretical frameworks. The compatibility between different studies on Secular Stagnation is particularly marked when I involve policy implications. In particular, I should distinguish between supply-side and demand-side policies, all of which have direct impact on productivity as well as on GDP growth. Broadly speaking, the majority of economists agree that boosting investments behooves in order to circumvent the problem, for instance through innovation policies and a greater efficiency allocation of productive resources.

Gordon, Eichengreen and Ramey – among the others – look mainly at the supply-side perspective of the economy and they provide a setting in which firms are allowed and provided with incentives to undertake the necessary investment projects. In such a framework, contrasting Secular Stagnation requires structural reforms for the improvement of the educational system, the development of more efficient infrastructures and administrative simplification for start-ups along with antitrust policies. Moreover, Glaeser (2014) focuses on individual-targeted policies, the most important of which considers the whole re-organisation of the American schooling system.

While I agree with the policy implications of the supply-side economists concerning to the improvement and the development of more efficient infrastructures and for the overall rethinking of the American schooling system, which should be modeled on the European one, I shall nonetheless recognise that the aforementioned supply-side policies must be matched with strong demand-side policies. More precisely, Summers (2015) and Hein (2016), among the others, recommend a set of strong fiscal policies based on three pillars, often named Global Keynesian New Deal. The first pillar is the re-organisation of the financial system, in order to increase the transparency and to shift shareholder's interest from short-term gains in the financial markets towards longer-term achievements in the real economy. Such a shift requires a higher profitability in the latter with respect to the former. The second pillar, connected with the first, demands that governments should increase and stabilize public autonomous expenditure growth. On the one hand, the public sector must invest on infrastructure, technology and R&D as it did during the Golden-Age period, thus creating the environment in which firms are willing to carry out new investments. Promoting exports constitutes a complementary policy and it may have a positive impact on the economic system through trade agreements and by prompting neo-mercantilist economies to rise demand for imports, thus benefiting other countries suffering from a lingering deficit in current accounts. Perhaps (not so) surprisingly, Summers (2015) finds that fiscal policies would manage to reduce debt-to-GDP ratio in the medium-long term, hence tackling the sustainability problem. On the other hand, governments should revise income policies: the progressive worsening experienced by personal as well as functional distribution of income should be stopped by wage-led actions as the strengthening of trade unions' bargaining power and through general reductions of shareholders' and rentiers' claims. The overall re-distribution of income must be accompanied by tax policies aimed at extracting more resources from profits and less from low and middle-income households, hence increasing the overall propensity to consume. Third, the wage-led recovery should take into account "the reconstruction of the international macroeconomic and monetary policy coordination and a new financial order so as to prevent export-led mercantilist [. . .] strategies" (Hein, 2016, p. 168).

Finally, Pagano (2014) suggests a *communism* of knowledge. Secular Stagnation needs a knowledge produced *in* and *for* the public domain. Each country must invest on it and to dodge free-rider problems and the widespread under-funding of many research institutions, at the expense of the ones which do invest, the international institutions, WTO *in primis*, must establish each country earmarks a GDP fraction for investments in common knowledge. This action requires the Marxian policy of asset redistribution, the liberal pro-market policy against monopolies and the Keynesian policy of public investments (Pagano, 2014). To conclude, Tab. 1.6 sketches an overview of what said so far on the explanations and policy recommendations on Secular Stagnation found in the literature.

1.7 Conclusions

The present chapter introduced the concept of Secular Stagnation, as defined by Hansen (1939), and examined its revival in the aftermath of the Great Recession by Prof. Summers and others. Through a very simple analysis on US data since 1870, I showed that the term

Determinants of Secular Stagnation	Negative Natural Rate Hypothesis	Productivity Slowdown: Supply Side	Productivity Slowdown: Demand Side
Main Concept	Shift in the natural balance between savings and investments lowered natural rate to negative values. Monetary policy is ineffective	*Headwinds* hit the pattern of technological change with a strong reduction in productivity growth	Shift in policy-making from full employment to price stability. Labour share shrinkage and financialization
Policy Prescriptions	Re-organisation of financial system. Expansionary fiscal policy	Improvements of educational system, infrastructures, administrative simplification for start-ups and antitrust policies	Global Keynesian New Deal: strongly expansionary government policies in infrastructure, technology and R&D; redistributive policies
References	Summers (2014a, 2015) Eggertsson et al. (2019)	Gordon (2012, 2015, 2017) Eichengreen (2015)	Hein (2015, 2016)
Criticisms	Di Bucchianico (2020); Palley (2019)	Acemoglu and Restrepo (2017); Crafts (2002); Ramey (2020)	Girardi and Pariboni (2020)

Table 1.6. Summary table

“Secular Stagnation” is somewhat misleading as used in the literature. On the one hand, it is applied to describe an economic system affected by an overall slowdown in real GDP per capita growth rate, when in fact this phenomenon consists of a return back to pre-Golden Age performances. Moreover, the growth rate in GDP per capita has been trendless since 1870. On the other hand, the Secular Stagnation hypothesis as formulated by Summers (2014a,b) suffers from serious theoretical drawbacks. He limits his analysis to the post-2007 world and the weak economic performances as resulting from the Great Recession. The crisis has persistently affected the economy for sure, but it is reductive to explain every cause in terms of economic cycles. Summers examines only the recent past. Additionally, Di Bucchianico (2020) and Palley (2019) clearly demonstrated that the idea on a negative natural interest rate itself, as promoted by Summers, relies on contradictory hypotheses which undermine its actual admissibility.
The most important contribution of this essay is that we should regard Secular Stagnation as a problem concerning to labour and multifactor productivity growth: their decline in growth since the 1970s cannot be associated with any return back to past performances. In that case we should even speak about a phenomenon that involves not a *single* long period, but possibly *more* long runs. My findings support (Hein, 2015, 2016)’s claim that stagnating-demand policies and the general increase of income inequality depressed investments and productivity growth, as well as more supply-side viewpoints *à la* Gordon (2014, 2015) and Eichengreen (2015). The two authors relate the decrease in productivity growth with the overall decline in population growth and the weakening in the propulsive thrust of the ICT technical change.

These heterogeneous contributions converge to a gradual homogeneity and complementarity when it comes to their policy implications. On the one hand, supply-side economists suggest the improvement of the educational system, the development of more efficient infrastructures and administrative simplification for start-ups and new businesses. On the other hand, a demand-side view focuses on strong fiscal policies for the stabilization of final demand. Active fiscal policies involve raising public spending to fight deflation and to contain the negative impact of an aggregate-demand crisis too. Furthermore they recommend the implementation of income policies is needed in order to stop the increase of income inequality, either personal or functional.

To conclude, the post-Golden Age era is characterized by slow growth in R&D expenditures and innovation activities. In particular, the slowdown in total and federal US R&D expenditures with respect to the Golden Age period (1950-72) is very remarkable . This evidence pools sectors as aerospace research, health and defense. The debate around Secular Stagnation in the United States paid little attention, if any, to the deep relationship between functional income distribution, firm innovative efforts and productivity growth; there is in particular a lack of a *demand-side* channel. In other terms, I will analyze in subsequent chapters whether the interactions between income distribution and innovation are able to provide us with further insights to explain the rise of Secular Stagnation in the USA. It would be interesting to show through an evolutionary perspective that innovation gains depend not only on supply-side factors, but it may be a demand story as well as in Caminati and Sordi (2019). Last sentences in (Hansen, 1939, pp. 14 – 15) make the point:

> There are no easy answers to the problems that confront us. And because this is true, economists will not perform their function if they fail to illuminate the rapidly shifting course of economic development, and through such neglect unwittingly contribute to a dangerous lag in adjustments to change. Equally they will not perform their function if they fail to disclose the possible dangers which lurk in the wake of vastly enlarged governments. Choices indeed must be made, and scientific analysis and painstaking research can aid by exploring the probable consequences of alternative choices. The problems which I raised offer a challenge to our profession. The great transition [. . .] calls for high scientific adventure along all the fronts represented by the social science disciplines.

Appendix A

Data Appendix

The careful reader that desires to replicate my results is referred to the following sources of data; the author can be contacted for any further doubt.

1. **Real GDP per capita**: The main source is the Jordà-Schularick-Taylor Macrohistory database, provided by the Macrohistory Lab Bonn, Release 4, 2019. In particular, the authors took data from Barro and Ursúa (2008) for the period 1870 – 2004. Data relative to 2005 – 2016 are drawn from World Bank, Category "Economic policy and external debt", Series "GDP per capita constant 2010 US$". For further information, check Jordà (2016); Jordà et al. (2017).

2. **Potential output**: Data are from the Ameco database provided by the European Commission. Data are accessible from `https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/macro-economic-database-ameco/ameco-database_en`. Select Chapter 6 "Domestic Product" and Sub-chapter 6.5 "Potential Gross Domestic Product at Constant Prices".

3. **Population**: Data comes from the Jordà-Schularick-Taylor Macrohistory database, provided by the Macrohistory Lab Bonn, Release 4, 2019. In particular, the authors drew information for 1870 – 2008 from the Angus Maddison Database (2008), Tab. 1 "Population levels, 1AD-2030AD". Estimates for more recent years, 2009 – 2016, have been taken from International Monetary Fund (2017), World Economic Outlook, Subject

"People-Population". Further details in Jordà (2016); Jordà et al. (2017).

4. **Labour Productivity**: The variable has been measured as GDP per hours worked. Penn World Table, 9.1 provides data since 1950. For any information, check the website https://www.rug.nl/ggdc/productivity/pwt/pwt-releases/pwt9.1?lang=en. In particular, I multiplied the average annual hours worked with the number of person engaged in order to compute the amount of hours worked. In contrast, I used data from Tab. A-III about GDP and from Tab. A-X about total manhours contained in Kendrick (1961) for the period 1889 – 1949.

5. **Total Factor Productivity**: Standard published measures of TFP concern the private non-farm business sector (Gordon, 2010). Therefore, I relied on Kendrick (1961) for 1889 to 1949 data, while on BLS data since 1950. In particular, I applied the simplest formula to compute the multifactor productivity:

$$tfp = y - n - b\,(k - n)$$

in which, $(y - n)$ represents the output growth minus growth in labour input (i.e. labour productivity), b is the capital share equal to 0.3, k is the capital input growth rate while the term $b\,(k - n)$ can be interpreted as the capital deepening effect. Data on capital input are from the private nonfarm nonresidential real capital stock as in Kendrick (1961), Tabs. A-XV and A-XVI and from private nonfarm business sector capital services as in BLS estimates. For further information, check https://www.bls.gov/mfp/.

6. **Gross Fixed Capital Formation**: the Ameco database of the European Commission provides data since 1960. Data can be obtained at https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/macro-economic-database-ameco/ameco-database_en. Select Chapter 3 "Capital Formation and Saving, Total Economy and Sectors", Sub-chapter 3.1 "Gross Fixed Capital Formation, Total Economy".

7. **Investment-to-GDP ratio**: Data are from the Jordà-Schularick-Taylor Macrohistory

database, provided by the Macrohistory Lab Bonn, Release 4, 2019. Precisely, the authors drew data on the variable from Mitchell (1998) for what concerns to the period 1870 – 1945. Remaining years, 1946 – 2016, are from International Monetary Fund, International Financial Statistics, Data Report ”National Account”, Series ”Gross Domestic Capital Formation, Nominal”. Further details in Jordà (2016); Jordà et al. (2017).

8. **Income Inequality, Bottom** 50% **Share**: Data are from the World Inequality Database. Pre-1962 information is drawn from Fisher-Post et al. (2020); Saez and Zucman (2020), while post-1962 data comes from Piketty et al. (2018). More information at https://wid.world/country/usa/.

9. **Income Inequality, Top** 1% **Share**: Data are from the World Inequality Database. Pre-1962 information is drawn from Fisher-Post et al. (2020); Saez and Zucman (2020), while post-1962 data comes from Piketty et al. (2018). More information at https://wid.world/country/usa/.

10. **Wealth Inequality, Bottom** 50% **Share**: Data are from the World Inequality Database. Pre-1962 information is drawn from Fisher-Post et al. (2020); Saez and Zucman (2020), while post-1962 data comes from Piketty et al. (2018). More information at https://wid.world/country/usa/.

11. **Wealth Inequality, Top** 1% **Share**: Data are from the World Inequality Database. Pre-1962 information is drawn from Fisher-Post et al. (2020); Saez and Zucman (2020), while post-1962 data comes from Piketty et al. (2018). More information at https://wid.world/country/usa/.

12. **Adjusted Wage Share**: The Ameco database of the European Commission provides data of the adjusted wage share as percentage of GDP at factor cost since 1960. Data are accessible from https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/macro-economic-database-ameco/ameco-database_en. Select Chapter 7 “Gross Domestic Product (Income Approach),

Labour Costs", Sub-chapter 7.6 "Adjusted Wage Share".

Chapter 2

Secular Stagnation and Innovation Dynamics: An Agent-based SFC Model. Part I

2.1 Introduction

Prof. Larry Summers re-evoked in recent times the old concept of Secular Stagnation to describe a situation in which changes in the economic fundamentals after the Great Recession of 2007 might have caused a significant shift in the natural balance between savings and investments, making the achievement of adequate growth, capacity utilisation and financial stability increasingly difficult (Summers, 2014b). Many economists dealt with that phenomenon thus far, each underlining a peculiar aspect.[1] However, the debate paid little attention to the deep relationship between income distribution, innovation and productivity.

The paper fills that gap in the literature and sets Secular Stagnation into an agent-based framework. I focus on the US capitalistic evolution of the last fifty years and study in which way the distribution of income between wages and profits can determine the rate of innovative activity and then further attainments in productivity. In particular, I depart from Summers' definition and look at Secular Stagnation in the USA as the tendency to the long-term slowdown in the growth rates of labour productivity which starts in the early Seventies and reaches the trough with the Great Recession in 2007. In what follows, I omit TFP concerns from the analysis: since the object of the paper involves agent-based modeling, any reference to TFP measures, even

[1] Eichengreen wrote that Secular Stagnation is like Rorschach test: it means different things to different people Eichengreen (2015).

for descriptive purposes, could seem wrongful. Moreover, I consider other major features of the US post-1972 economy like the progressive worsening of the functional distribution of income at the expense of the labour share and, on the other hand, a slower growth in R&D activity.

The theoretical and specific contribution to the literature on Secular Stagnation lies on the capability to show the way phenomena at the macro-level affect the dynamic path of variables at the micro level, and vice-versa. More precisely, it is interesting to show that the shrinkage of the labour share impacts negatively on firms' propensity and ability to innovate. Wages indeed sustain consumption and, indirectly, investments. The lower aggregate demand after a fall in the wage share reduces capitalist's incentive to invest either on tangible capital or on innovative search at the micro-economic level. The result will be an overall bad economic performance on aggregate. I advance the idea that the continuous shift of income from wages to profits may have resulted in a smaller incentive to invest in R&D activity, entailing the evident decline in aggregate productivity performances that marks the US Secular Stagnation. I have to admit, of course, that this is not the only valid explanation for the long-run tendency of productivity growth to fall. Non-technological motives, like lower top marginal tax rates, increased low-skill immigration, rising trade with China and low-cost manufacturing countries or the rise of superstar firms (Autor et al., 2020) are equally plausible.

I additionally focus on the role exerted by the rate of interest and the loosening of barriers to innovation and imitation. On the one hand, the decrease in the interest rate helps increase aggregate production and employment levels but impacts negatively on the share of income going to labour, since the entrepreneurs reach greater profit levels and prefer organizing the production process to less labour-saving techniques. On the other hand, loosening the barriers to the interaction among firms and increasing the possibility to exchange ideas through imitation allow for further innovation and better economic performances as a whole, but the effect is little and circumscribed to the long run only.

For what concerns to the model, it involves a one-good two-class closed economy with no government sector. The good can be used either for consumption or for investment purposes. Households consist of workers, that supply labour inelastically at the going wage rate, and capitalists, which own the firms and act as entrepreneurs. The latter invest in innovative research activity a percentage revenue from past sales according to the discrepancy between the actual and the normal profit rate. For my specific purpose, the rationale to adopt an agent-based framework is at least threefold and builds upon the *macro-to-micro* and *micro-to-macro* channels. For what concerns to the former route, crucial phenomena such as the bargaining process between workers and entrepreneurs occur at the macro-economic level. The outcome of the social conflict has strong repercussions at firm level, since it influences entrepreneurial decisions about innovative search, employment and firm's competitiveness from the *cost* side. In addition to this, aggregate demand from households endogenously shapes the way for production and pricing determinations on the *revenue* side. On the contrary, the *micro-to-macro* channel results essential in defining the market structure, its evolution over time and firms size distribution. They in particular find directly out aggregate employment and production, and endogenize the bargaining process above. More importantly, they steer the aggregate dynamics of innovation and productivity which are central to the *specific kind* of Secular Stagnation I choose to deal with.

Furthermore, there are more general reasons on why I developed a model and an agent-based model in particular. Albeit several scholars expanded upon the literature on Secular Stagnation in last years, there is still a scarcity in modeling. Eggertsson et al. (2019) is one of the few attempts to build a solid and quantitative framework to explain the surge of the peculiar form of Secular Stagnation as envisaged by Summers. Precisely, they develop an analytic overlapping generation model, the steady state of which is characterized by a negative full-employment real interest rate. Among the criticisms that can be raised to Eggertsson et al. (2019) (cf. Di Bucchianico (2020)), the absence of substantial heterogeneity among agents and of complicate interaction patterns is certainly a weakness of the model. (Pyka and Fagiolo, 2005, p. 5) clearly established that, "the strong consistency requirements induced by hyper-rationality compress any sequence of decisions made over time by the agents into a single and coherent stream of decisions made once and for all in a unreversible manner. These models can generate only equilibrium outcomes, and *only* equilibrium observations can be observed in reality". By contrast, agent-based models are particularly suitable to the task since the user knows by construction the micro data-generating process and can explore the features of macro-variables as properties emerging out of the evolutionary dynamics (Dosi et al., 2018). Furthermore, neoclassical models such that by Eggertsson et al. (2019) do not manage to study the endogenous introduction of innovations by agents, while innovative behaviours within an environment featured by true uncertainty is a central trait of all agent-based models. Last but not least, the latter kind of modeling recognizes, on the one hand, the importance of Solow (2008)'s call for micro-foundations more realistic than usual. On the other hand, micro-foundation is absent in many macro-aggregate models, which do not enable the researcher to fully understand processes occurring at the micro- and meso-level of economic activity.

The paper is organised as follows: Section II deals with the literature; Section III presents empirical evidence on income distribution, innovation and productivity; Sections IV to VI are about the model and related experiments; Section VII concludes. The Appendices convey information on data and main matching protocols. Although the model approaches to a stationary state and does not refer to *growth* questions (yet), it represents the first step toward the development of a growth model. The latter will be developed in Part II.

2.2 Relation with the literature

Several fields of research contribute to define the background literature of the present work. First and foremost, the paper inserts into the literature of Secular Stagnation, here defined as the tendency to the long-term slowdown in the growth rates of labour productivity, which starts in the early Seventies and reaches the trough with the Great Recession of 2007.Though related to a different context, the concept was introduced with the pioneering work by Hansen (1939) to describe the somber situation in which the US economy fell after the Great Depression in 1929. The author looked at the high unemployment as the principal problem for Americans and the expression of Secular Stagnation stood for "sick recoveries which die in their infancy and depressions which feed on themselves and leave a hard and seemingly immovable core of unemployment" (Hansen, 1939, p. 4). To date, Summers (2014b) re-evoked the concept to outline a situation in which changes in the economic fundamentals, after the Great Recession, might have led to a significant shift in the natural balances between savings and investments. The equilibrium natural interest rate associated with full employment of labour would have reached negative values. The related outcome is a situation in which the achievement of adequate growth, capacity utilisation and financial stability appears increasingly difficult (Summers, 2014b). However, his analysis is limited in scope in that he focuses on Secular Stagnation through the lens of the Great Recession only. Summers examines the very recent past and the remarkable decline in productivity growth finds no place in that framework.

Additionally, the (negative) natural rate hypothesis suffers from important theoretical weaknesses (Di Bucchianico, 2020; Palley, 2019).

Many economists recovered the concept after him: we find Gordon (2015), Eichengreen (2015) and Hein (2016), among the others. Their approach is historical data driven. On the one hand, Gordon (2015) and Eichengreen (2015) adopt a supply-side view to analyze the long-period determinants of productivity growth and disregard cyclical influences. They suggest that mounting inequality impacted negatively on the accumulation of human capital, since students are ever more burdened by the loans they take to pay their college tuition. Furthermore, they are concerned to the revolution started by digital electronics, which ran out of steam, with the electronics facing diminishing returns. Their idea is that innovation achievements of the last fifty years had a relatively smaller impact on productivity than, for example, innovations at the turn of the XX^{th} century. On the other hand, Hein (2016) points out as the redistribution of income at the expense of the labour share squeezed investments in capital stock through an accelerator mechanism. Moreover, the author claims that stagnating-demand policies and the overall surge of personal income inequality depressed investments and productivity growth.[2]

The second stream of research is about the Schumpeterian and evolutionary tradition (Aghion and Howitt, 2008; Bowles, 2009; Nelson, 1982; Nelson and Winter, 1982; Schumpeter, 1934). It deals with "dynamic processes causing qualitative transformation of economies driven by the introduction of innovation in their various and multifaceted forms and the related co-evolutionary process" (Hanusch and Pyka, 2007, p. 280). Innovation turns out to be the most important force driving productivity and economic growth. Moreover, it is strongly related with uncertainty in its *Knightian* sense, causing complex modes of behaviour. Although innovation occurs at the micro-level of the economy through the creation of novelties and many entrepreneurial decisions, its potentiality manifests at the industry or *meso*-level of the economic activity (Dopfer et al., 2004). An eminent precursor of evolutionary and complex economics is Von Hayek (1937) with the notion of *spontaneous order*, in which chaotic processes at the micro-economic level may entail some form of regularity at the macro-aggregate perspective. Markets are viewed as places for learning and discoveries, hence a place for innovation and imitation. In that framework, the evolution of institutions is the product of

[2] I should remark that Hein (2016) contrasts the concept of Secular Stagnation to that of Stagnation Policy. I believe that such a juxtaposition could be misplaced: the former should concern to some stylized fact or empirical evidence, while the latter to the rationales. Anyway, I do not discuss that since it is beyond the scope of the present work.

countless interactions, the aggregate outcome of which is often unintended (Bowles, 2009).

Third, I refer to the agent-based (AB, hereafter) literature, that considers economic systems as populated by many heterogeneous interacting agents without any central coordination (Caiani et al., 2016b). More precisely, "[A]n agent-based model is a computerized simulation of a number of decision-makers (agents) and institutions, which interact through prescribed rules. [. . .] Such models do not rely on the assumption that the economy will move towards a predetermined equilibrium state, as other models do. Instead, at any given time, each agent acts according to its current situation, the state of the world around it and the rules governing its behaviour" (Farmer and Foley, 2009, p. 685). Economies are seen as complex dynamic systems, whereby a multitude of micro-agents locally interacts continuously and gives rise to the multi-faceted global stylized facts for growth rates, employment, income distributions and institutions. At the same time, these macro-outcomes feed back into the local interactions (Tesfatsion, 2006; Tesfatsion and Judd, 2006). The loop results in the agent's learning through the change in her behaviour based on past experience. The most important pro of ACE modeling, compared to the standard Walrasian methodology, is that agents are designed with more autonomy and with the capacity of self-regulating (LeBaron and Tesfatsion, 2008; Tesfatsion, 2002, 2006). In this respect, AB models have been developed in juxtaposition and in alternative to rational-expectations DSGE models.[3]

Models of this kind are present in many areas of economics to analyse the emergence of trading behaviours in goods-market (Tesfatsion, 2006), evolving dynamics and instabilities in financial markets (Assenza et al., 2015; Delli Gatti et al., 2005, 2010; Riccetti et al., 2015), issues concerning innovation and industry evolution (Dosi et al., 2010), the relationship between income distribution and education (Kinsella et al., 2011), and the effect of consumption and production on structural change (Ciarli et al., 2010, 2019; Lorentz et al., 2016).

Among this broad literature, I have to mention the EURACE project, which is a massive attempt to design and implement an AB macroeconomic platform for the whole European economy (Deissenberg et al., 2008). This attempt encompasses and subsequently unifies several environments, such as consumption and investment goods markets, labour markets and markets for financial assets. Inspired by real-world empirical evidence, EURACE adopts

[3] "[M]ainstream macroeconomics lacks the adequate conceptual and analytical tools to accomplish such an endeavor. Its reductionist methodology implies that in order to understand the working of the system, one has to focus on the working of each single element. Assuming that elements are similar and do not interact [. . .] the dynamics of the aggregate replicate the dynamics of the sub-unit. This assumption requires that every element is in equilibrium" (Delli Gatti et al., 2005, p. 491).

realistic assumptions about agent's bounded rationality and limited information managing capacity. The framework contributes to several areas of research, like the investigation of the interplay between skill distribution, technological change, employment and wage dynamics (Deissenberg et al., 2008); the relationship between debt deleveraging, credit money and financial instability (Cincotti et al., 2010; Raberto et al., 2011); and the effectiveness of different types of cohesion policies with respect to convergence of regions (Dawid et al., 2014).

Although I extensively draw upon this literature, most for what regards learning behaviours, markets of interaction and matching protocols, I recognize that AB models are not a panacea and suffer from some drawback (Farmer and Foley, 2009). Broadly speaking, detailing all the relevant aspects of an economy does rapidly result in a significantly complicated model in which it is difficult, at best, to discern what causes what. The EURACE project, for example, achieved an increasing popularity among scholars but its complexity strongly limits the logic accessibility of the model and its re-usability by other researchers (Caiani et al., 2016a); additionally, economists need massive supercomputers to run that framework, which are usually not at their means. Furthemore, many former AB models violated accounting consistency requirements, with some financial flows arising out of nowhere. Caiani et al. (2016a) starts from this point and builds a fully decentralised stock-flow consistent model with heterogeneous interacting agents, in which consistency is applied since the micro-economic level to account for the structural interrelatedness of agents. Although the model does not concern to *growth* questions, it is promising in the field of bank regulation and macro-prudential issues. This contribution offers interesting guideposts to calibrate, validate and adapt the basic framework to alternative research questions.

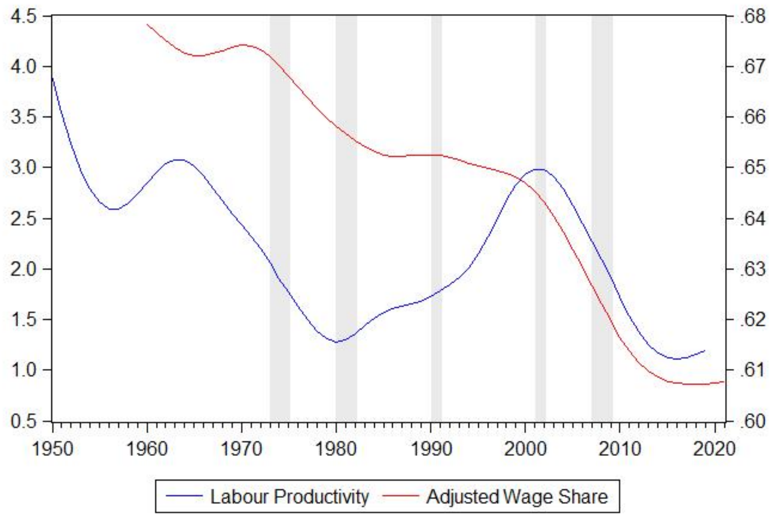
2.3 Statistics on wages, productivity and innovation since 1950

I said that the literature on Secular Stagnation paid little attention to the interplay between income distribution, innovation and productivity developments. The mounting shift of income from wages to profits, on the one hand, and the reductions in productivity growth, on the other, have manifested since the end of the Golden Age of capitalism (1950-1973). Hence, what I represent in Tab. 2.1 and in Fig. 2.1 is a well-documented fact in the economic debate. Starting from the late Sixties, when it was near to 70%, the adjusted wage share keeps decreasing to the current minimum value around 60%. For what regards to labour productivity, there was a slow

Time - Variable	Adjusted wage share	Labour Productivity
1950 – 1973	0.674	0.027
1973 – 1995	0.656	0.017
1995 – 2007	0.642	0.026
2007 – 2019	0.613	0.015

Note: author's own calculations on Ameco and BLS data. Data on wage share are available since 1960. I applied the HP-filter to focus on the trend component only.

Table 2.1. Average wage share and average growth rates for labour productivity



Note: left axis refers to productivity growth rate, right axis to the wage share; shaded areas indicate major crises; I reported results of the HP-filter trend component of real time series so to focus on the long-run component. Source: author's calculations on Ameco and BLS data.

Figure 2.1. US adjusted wage share and productivity growth rate, 1950-2018

and steady decline in the growth rate over the period of interest. The rate of growth exhibits a timid recovery in the Nineties, before the new and long-lasting collapse in the aftermath of 2007 crisis. Gordon (2015) suggests that soaring inequality impacted negatively on the accumulation on human capital and then on productivity, since students are ever more burdened by the loans they take to pay their college tuition. On the demand side, Hein (2016) points out that the redistribution of income at the expense of the labour share lowered investments in capital stock through an accelerator mechanism. For what concerns to the relation between innovation and productivity, the literature refers to Eichengreen (2015) and still to Gordon (2015). Their idea is that the innovation achievements of the last fifty years had a relatively smaller impact on productivity than, for example, innovations at the turn of the XX^{th} century.

What is missing on the analysis around Secular Stagnation is the *demand-side* channel be-

Time - Variable	Federal	Other - Gov't	Industry	Non-profits	University	Total
1953 – 1973	0.028	0.032	0.027	0.035	0.036	0.028
1973 – 1995	0.004	0.014	0.022	0.023	0.028	0.014
1995 – 2007	0.008	0.016	0.016	0.030	0.023	0.014
2007 – 2017	−0.001	0.005	0.014	0.021	0.019	0.010

Note: author's own calculations on AAAS data. Data are available since 1953 for each variable. I applied the HP-filter to focus on the trend component only.

Table 2.2. Average growth rates in US R&D expenditures by source

Time - Variable	Defense	Energy	General Science	Health	Natural Resources	Non-defense	Other	Space
1953 – 1973	0.027	0.066	0.043	0.065	0.042	0.062	0.046	0.082
1973 – 1995	0.008	0.003	0.005	0.018	0.005	0.002	−0.001	−0.011
1995 – 2007	0.012	−0.024	0.023	0.025	−0.004	0.013	0.003	−0.001
2007 – 2018	−0.020	0.019	0.006	0.001	0.002	0.002	−0.004	0.002

Note: author's own calculations on AAAS data. Data are available since 1953 for each variable. I applied the HP-filter to focus on the trend component only.

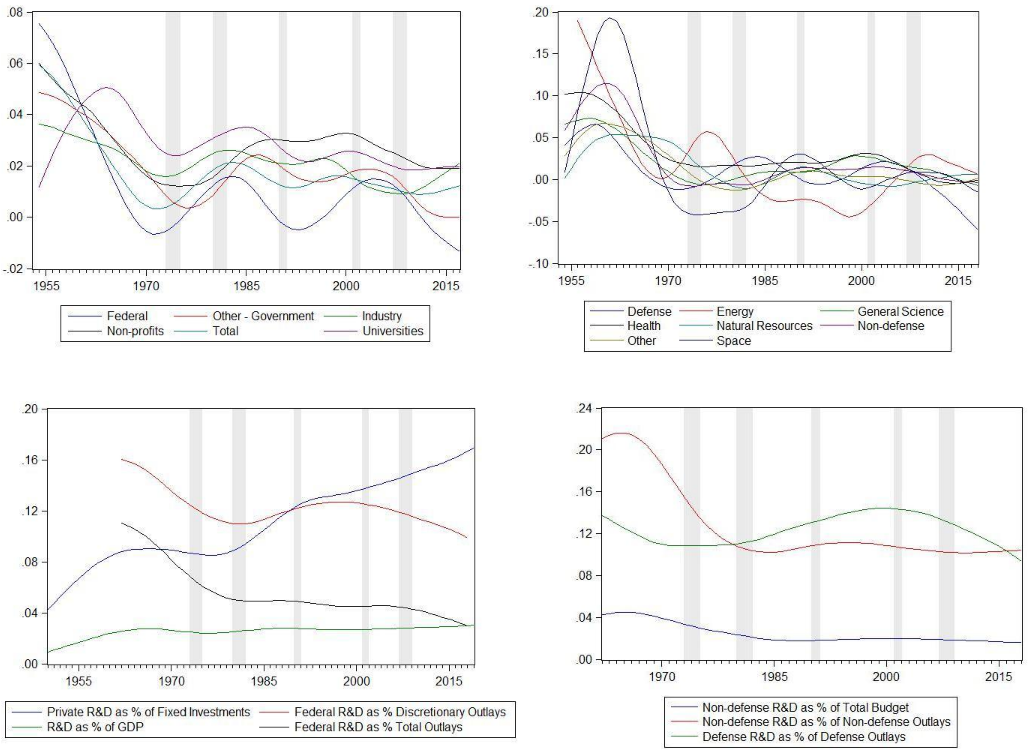
Table 2.3. Average growth rates in US Federal R&D expenditures by function

tween functional distribution of income, innovation and productivity. Sylos-Labini (1983) first, and Allen (2009, 2011) and Carnevali et al. (2020) later, explain the role of a distribution favourable to the wage share in triggering a process of economic development, through continuous investments on innovative activities and further achievements in productivity. Is it possible that the same process occurred in the opposite way? In other terms, does any positive relation exist between wage share, investments in R&D and productivity enhancements? Tabs. 2.2 to 2.6 and Fig. 2.2 present data on the evolution of R&D expenditures in United States since 1950, whenever possible. Tabs. 2.2- 2.3 and the upper panels of Fig. 2.2 evidence the striking decline in growth of R&D expenditure since late 1960s, either *by source* or *by function*.[4] The careful observer may object that the Golden Age in US was a particular period marked by the necessity of *winning* the Cold War against the Soviet Union. It would explain why, for instance, space expenditure growth rates surged toward extraordinary values until the end of the Sixties and then fell sharply after the first moon landing. Therefore, I analyzed the time trend of each variable since 1973, finding that the majority of sources and functions exhibited a steadily downward trend in growth.[5]

Tabs. 2.4- 2.5 and the lower panels in Fig. 2.2 concern to the evolution of R&D shares. It is interesting to notice that private R&D as percentage of Fixed Investments kept increasing throughout the period, the decline in growth showed above notwithstanding. Furthermore, Arora et al. (2018) notes a shift away from science by large corporations between 1980 and

[4]Categories are established by the AAAS database. Check Data Appendix for definitions and details.

[5]For the sake of brevity, I did not report tables on trend regressions, since what asserted is visible in Tabs. 2.2- 2.3 and Fig. 2.2. Anyway, they are available upon request.



Note: top-left graph points to R&D expenditure by source, top-right graph refers to R&D expenditure by function, bottom graphs point to R&D shares in some aggregate; shaded areas indicate major crises; I reported results of the HP-filter trend component of real time series so to focus on the long-run component. Source: AAAS data.

Figure 2.2. US R&D expenditures, 1953-2018

Time - Variable	R&D as % of GDP	Private R&D as % of Fixed Investments	Federal R&D as % of Discretionary Outlays	Federal R&D as % of Total Outlays
1950 – 1973	0.022	0.078	0.144	0.092
1973 – 1995	0.026	0.104	0.117	0.052
1995 – 2007	0.027	0.137	0.124	0.045
2007 – 2018	0.029	0.155	0.109	0.038

Note: author's own calculations on AAAS and BEA data. Data are available since 1962 for variables referred to Federal R&D. I applied the HP-filter to focus on the trend component only.

Table 2.4. R&D shares, I

Time - Variable	Defense as % of Defense Outlays	Non-defense as % of Total Budget	Non-defense as % of Non-defense Outlays
1962 – 1973	0.119	0.041	0.197
1973 – 1995	0.120	0.022	0.114
1995 – 2007	0.141	0.019	0.107
2007 – 2018	0.116	0.017	0.103

Note: author's own calculations on AAAS data.

Table 2.5. R&D shares, II

2006. Although science remains an important input for innovation, their empirical evidence points to a reduction of the private benefits of internal research, which leads to closing and downsizing their labs. Although Bloom et al. (2020) agree on this point too, I must point however that innovative investments in the private sector is now very disseminated in a multiplicity of small-size firms and start-ups, often unrelated to the investing firm from a *corporate* point of view. This feature may invalidate, at least partially, the empirical evidence by Arora et al. (2018). Anyway, albeit firms are committing a higher share of investments in R&D, it does correspond to the redirection of resources and attention from more exploratory scientific research toward more commercially-oriented projects (Arora et al., 2018). By the same token, federal R&D shares kept decreasing from late 1960s onwards, either as share of discretionary outlays or as share of total budget (Tab. 2.5).[6] Moreover, they kept decreasing regardless to the destination, whether defense or non-defense.

To sum up, Tab. 2.6 shows that wage share, innovation rates and productivity measures are significantly and positively correlated. I advance the idea that the ongoing shift of income from wages to profits may have resulted in a smaller incentive to invest in R&D, entailing the evident decline in productivity growth. Secular Stagnation might have originated from that. In what follows I develop an agent-based SFC model to highlight whether the hypothesis grounds on a micro-founded framework too. AB models are particularly suitable to the task since one knows by construction the micro-economic data-generating process and can explore

[6] Check Data Appendix for details about the definition of discretionary outlays and total budget.

Variables	Adjusted Wage Share	Labour Productivity	Federal	Industry	Non-profits	Other - Gov't	Universities	Total
Adjusted Wage Share	1							
Labour Productivity	0.354***	1						
Federal	0.319***	0.294***	1					
Industry	0.512***	−0.349***	0.185	1				
Non-profits	−0.040	0.174	0.409***	0.196	1			
Other - Gov't	0.555***	0.445***	0.602***	0.417***	0.680***	1		
Universities	0.702***	0.286**	0.496***	0.710***	0.221	0.770***	1	
Total	0.158	−0.207	0.739***	0.655***	0.564***	0.522***	0.538***	1

Note: author's own calculations. Star significance: *** $p < 0.01$, ** $p < 0.05$ and *$p < 0.1$.

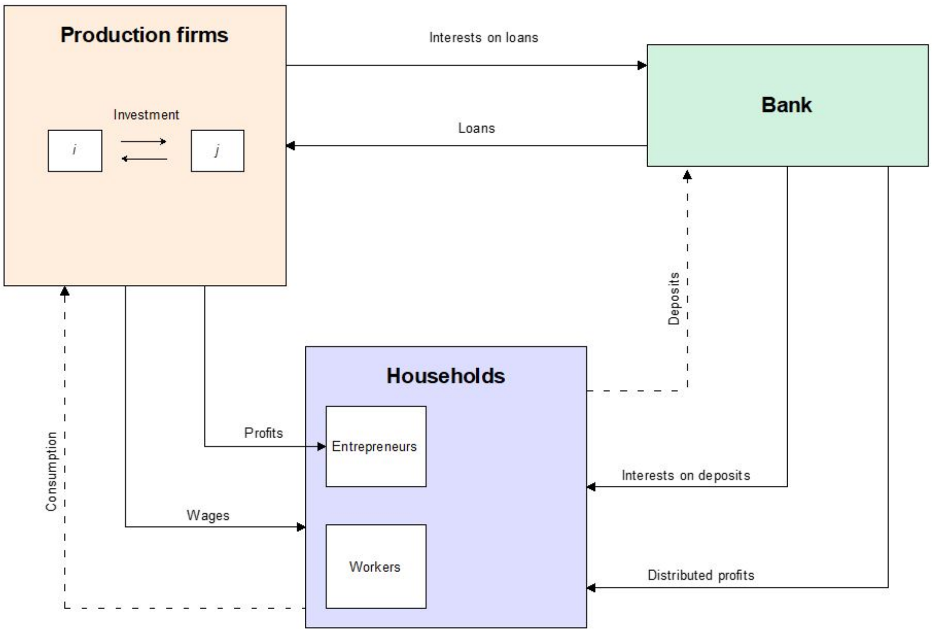
Table 2.6. Ordinary correlation among some variables

the characteristics of macro-economic variables as properties emerging out of the evolutionary dynamics (Dosi et al., 2018).

2.4 A model for Secular Stagnation

The analysis concerns to the role of income distribution and demand in affecting the economic performance. I focus on a one-good two-class closed economy with no government sector that approaches to and gravitates around a stationary state. Following Caverzasi-Godin (2015), I define a stationary state as a logical construction where all stocks and flows do not change over time and that can be reached if all the behaviours were *fixed* after a transition period. Moreover, the stationary of the model comes out the hypotheses that workers bargain over wage levels, on firm's decisions about investment activities and on agents' learning methods. I deal with a stationary state economy for two reasons. Firstly, the framework is also inspired by the SFC literature, which usually considers economies gravitating around stationary states. Secondly and more importantly, I am here interested, on the one hand, in the conditions that guarantee the reproduction of the economy on the same scale over time and, on the other hand, in the influences of the social conflict between workers and entrepreneurs on firm's investment decisions. This *macro-to-micro* channel, on which aggregate productivity performance hinges upon, does not require economic growth as an essential feature. It allows me furthermore to keep the model simple in the first stage and to add further complications and extensions later on. The only necessary requirement is the ability of the economy to reproduce on an invariant scale through time, with neither tendency to explode nor collapse.

The economy is populated by heterogeneous interacting agents as in Fig. 2.3. The model is complex, adaptive and structural in the spirit of Tesfatsion (2006): *complex* because the sys-



Note: arrows point from paying sectors to receiving sectors.

Figure 2.3. Flow diagram of the model

tem involves interacting units; *adaptive* since it concerns to environmental changes; *structural* because built on what agents do. Precisely we have:

- A collection N_s of households: on the one hand, $N_s - F$ agents offer labour inelastically at the going wage rate; on the other hand, the remaining households are capitalists. Regardless of their status, households spend part of their income in the purchase of the (consumption) good. Savings are held in the form of bank deposits, only and always. Moreover, they own the bank proportionally to their wealth and receive banking profits as dividends.

- A collection F of firms owned by the entrepreneurs organizing the production process and taking investment decisions. They produce a homogeneous good that can be used either for consumption or for investment purposes. Entrepreneurs may apply for loans to finance production and investment.

- A consolidated bank, whose activity is limited to providing firms with loans and households with deposits at given interest rates. So doing, the big bank is an input supplier as in Deissenberg et al. (2008).

During each period of the simulation, agents interact on five markets:

- The (capital) goods market: firms interact with each other to buy and sell (capital) goods.
- The (consumption) goods market: households purchase (consumption) goods from firms.
- The labour market: capitalists interact with workers through hiring and firing.
- The credit market: the consolidated bank provides firms with loans.
- The deposit market: the consolidated bank gathers households' deposits.

The behavioural equations for households and firms are in line with the agent-based SFC literature as in Caiani et al. (2016a,b) and Godley and Lavoie (2006). There is not population growth; however, labour supply is exogenous and unbinding, since in a mature capitalist economy as the USA are there is usually a pocket of unemployment, while episodes of labour shortages, if any, are solved through exogenous migration flows. A crucial feature of the model is the role assumed by innovation, which turns out to be the driver of productivity and economic development. Though it occurs at the micro-level of the economy through several entrepreneurial decisions, its potentiality gets fully fledged at the industry or meso-level of the economic activity. The model exhibits evolutionary roots since it envisages path dependencies and irreversibilities, since the heterogenous agents show close and frequent interactions and the "outcome of evolutionary processes is determined neither *ex ante* nor as a result of global optimizing, but rather is due to true uncertainty underlying all processes of novelty generation" (Hanusch and Pyka, 2007, p. 278).

For the sake of simplicity, I split the exposition as follows: timeline of events, production firms, labour market, households, innovation and imitation processes, banking system, prices and inflation expectations.

2.4.1 Timeline of events

Production firms are endowed with a unit of (capital) good at $t = t_0$. After that, micro-economic decisions occur with this sequential order any given period t:

1. Firms compute their target level of capital.
2. Capitalists draw from previous accumulated profits, if any, and borrow from the banking system in order to have enough fund to hire workers and buy the (capital) goods they

need. They set up production to build the (capital) goods they are ordered by the other firms and to satisfy the demand for (consumption) goods from households.

3. Workers receive a wage. Regardless of their status, agents purchase the (consumption) good with part of the received income and save as bank deposits what remains. Businessmen earn profits as a residual claim, if any.

4. The aggregate bank gathers interest payments from firms and pays interests on households' deposits. Then, it distributes profits to households.

5. Firms update their production plans according to the demand they face. Moreover, they invest on capital stock and on R&D to improve their technology level, save manpower and earn further – extra – profits. New machines and productivity enhancements due to the R&D activity, if any, will be available at $t+1$.

2.4.2 Production firms

I start describing how production takes place and how entrepreneurs take their decisions. The economy produces a single good that can be used either for consumption or for investment purposes. There are no inventories and production adapts to demand. Output components are all expressed at constant prices. The first equality is about production at firm level:[7]

$$y_j = c_{f,j} + i_{s,j} + i_{rd,j} \tag{2.1}$$

in which y is the amount of good produced by the single firm, split into production of (consumption) and (capital) goods, and innovative activity respectively, while j always refers to the single firm if not otherwise specified. The production technology employs labour and capital in fixed proportions, following the usual Leontief production function:

$$y_j^P = min\left[\varphi \cdot k_j; a_j \cdot N_s\right] \tag{2.2}$$

in which y^P is the productive capacity of the i-th firm, k its capital endowment, φ the inverse of the capital-output ratio while a is the labour productivity within the same firm. Entrepreneurs target a certain capital stock k^T. Even if production adapts to demand, firms maintain excess capacity and this excess does not reflect a wrongful process of expectations

[7] In what follows, lower case letters denote micro-economic variables and parameters while capital letters refer to aggregate variable.

formation, but rather the rational decision of the firm to be able to accommodate fluctuations in demand (Ciccone, 1986). In addition to this, a further clarification is apt: I hypothesize productivity improvements result in different technologies. This hypothesis allows to keep the capital *productivity* as constant through time; the same holds for the capital to labour ratio along the same technology. The adoption of new technologies leads to discrete jumps in the capital to labour ratio, which keeps its constancy with respect to a given technology. For simplicity, a constant proportion δ of the existing stock of capital depreciates period-by-period and capitalists set aside an amount of funds exactly sufficient to replace the used-up equipment:

$$da_j = \delta \cdot k_{t-1,j} \tag{2.3}$$

$$af_j = da_j \tag{2.4}$$

da and af define the depreciation allowances and the amortization fund, respectively.
Let us turn on the investment decisions. The entrepreneurs distinguish between investments on tangible capital – i.e. machines – and intangible capital – i.e. R&D. Investments on tangible capital increase the productive capacity but do not improve technology and labour productivity, whereas investments on R&D do. Since inventive activity is costly, capitalists have two alternatives: capital accumulation and innovation. Both types of investment raise total earnings, but in different ways: innovation reduces unit labour costs in production, while capital accumulation increases the size of a firm's business. For simplicity, there is no trade-off between different types of investment. Gross investments on tangible capital consist of a modified version of the standard partial-adjustment accelerator model:

$$i_{k,j} = i_0 + i_{1,j} \cdot \left(k_j^T - k_j\right) + af_j \tag{2.5}$$

in which i_k, i_0 and i_1 represent the investment in physical capital, the autonomous and exogenous investment or *animal spirits* and the adjustment coefficient, respectively.
Firms invest in innovative search to save labour and to earn extra-profits. In line with the Schumpeterian literature, I posit the amount invested in innovative activity is made up of two components:

$$i_{rd,j} = \vartheta_{0,j} \cdot c_{f,av,j} + \vartheta_{1,j} \cdot \left(\varrho_j - \bar{\varrho}\right) \tag{2.6}$$

The first component on the right-hand-side, $\vartheta_{0,j} \cdot c_{f,av,j}$, captures firm's expectations about future demand that are equal a paramenter, $\vartheta_{0,j}$ applied to the average revenue from past sales of consumption goods, $c_{f,av,j}$.[8] The other component reflects the cost side of the expected profit rate, provided that the actual profit rate ϱ is an indicator for expected profitability $\bar{\varrho}$. Firms' profits are sales minus amortization fund, interest payments on past loans and wages:

$$f_j = y_j - af_j - r_l \cdot ld_{t-1,j} - wb_j \tag{2.7}$$

in which r_l is the given interest rate, ld_{t-1} the stock of loans from the past and wb the wage bill.

An important clarification is now necessary: i_k and i_{rd} represent the expenditure each firm does to ameliorate its technology. Since the expenditure related to the investment in capital stock is commissioned to other firms, I call (2.8) the investment *demand*. The random pattern of interactions among firms leads to a configuration in which the single firm produces an average amount of (capital) goods for the others, as in (2.9):

$$i_{d,j} = i_{k,j} + i_{rd,j} \tag{2.8}$$

$$i_{s,j} = \bar{i}_{k,j} \tag{2.9}$$

The capital stock, k, is the result of past (depreciated) equipment plus gross investments in physical capital i_k:

$$k_j = (1-\delta) \cdot k_{t-1,j} + i_{k,j} \tag{2.10}$$

To conclude this subsection, how do firms fund their (net) investments? We have three options. First, all net investment is financed out of new loans; second, all net investment is financed out of internal funds; third, the net investment is funded partly out of accumulated profits and partly out of new loans. I adopt the third way and suppose the entrepreneur contributes to fund her investment decisions with part of past retained profits, say $q \cdot mh_j$, while the remaining need will be financed out of new loans as follows:

$$dl_{d,j} = i_{d,j} - af_j - q \cdot mh_{t-1,j,e} \tag{2.11}$$

in which dl_d is the change in loans demand and q is the share of past (re-invested) profits

[8] "Firms in the capital-good industry "adaptively" strive to increase their market shares and their profits trying to improve their technology both via innovation and imitation. Both are costly processes: firms invest in R&D a fraction of their past sales" (Dosi et al., 2010, p. 1751).

mh. Furthermore, the single firm can borrow whatever sum it needs from the banking system at a constant rate r_l for convenience.

2.4.3 Labour market

Each firm needs a certain amount of effective labour to set out production, i.e it must consider the productivity of each worker within the enterprise. Denoting with a the effective labour productivity, the labour demand nd for the single firm is:

$$nd_j = \frac{y_j}{a_j} \tag{2.12}$$

The distribution of income at firm level is divided between profits and wages. Worker receive a wage rate whereas entrepreneurial profits are a residual. I can translate what said in the following equations:

$$w_r = \left(w_0 - w_1 \cdot U_{r,t-1}\right) \cdot PR_t \tag{2.13}$$

$$wb_j = w_r \cdot nd_j \tag{2.14}$$

The first equation identifies the wage rate w_r as the result of the positive constant w_0 and it is a negative function of the unemployment rate U_r. The wage rate is updated every period to account for inflationary pressures, as denoted by PR_t. (2.13) says the lower the unemployment rate and the higher the inflation expectactions, the higher the wage rate. The wage bill at firm level wb is the simple product between the wage rate and the number of employees. I mentioned earlier that the labour supply is exogenous and unbinding. I integrate it with the assumption that every worker is willing to accept a job at the going wage rate. Therefore, no firm faces (labour) supply constraints. The setting admits no over-employment but unvoluntary unemployment.

2.4.4 Households

Households consume and save. They are distinguished between capitalists and workers according to their propensity to save. The flows of income they may receive consist of four components: wage rate, entrepreneurial profits, an amount of bank's profits proportional to their wealth, $\sigma_{mh} \cdot F_{b,t}$, and interest payments on past deposits int_{mh}.[9] I write the households

[9] In which $\sigma_{mh} = \frac{m_h}{M_{h,t}}$, being $M_{h,t}$ the aggregate amount of wealth.

disposable income ydh_i as equal to:[10]

$$ydh_i = \begin{cases} f_i + \sigma_{mh,i} \cdot F_{b,t} + int_{mh,i} & \text{if} \quad i = e \\ w_r + \sigma_{mh,i} \cdot F_{b,t} + int_{mh,i} & \text{if} \quad i = w \end{cases} \tag{2.15}$$

For simplicity, agents consume part of their disposable income and part of their accumulated wealth, which takes the form of deposits. For convenience, I suppose households differ in the way they consume the income out of work. No difference exists in the way they consume wealth, interest payments and banking profits, since the marginality of this consumption component.

$$c_{inc,i} = \begin{cases} \alpha_0 + \alpha_{1,i} \cdot w_{r,t-1} + \alpha_{3,i} \cdot (\sigma_{mh,i} \cdot F_{b,t} + int_{mh,i}) & \text{if} \quad i = w \\ \alpha_0 + \alpha_{2,i} \cdot f_{i,t-1} + \alpha_{3,i} \cdot (\sigma_{mh,i} \cdot F_{b,t} + int_{mh,i}) & \text{if} \quad i = e \end{cases} \tag{2.16}$$

$$c_{wea,i} = \alpha_{3,i} \cdot m_{h,t-1,i} \tag{2.17}$$

$$c_i = c_{inc,i} + c_{wea,i} \tag{2.18}$$

(2.16) says the current consumption out of income is composed of an autonomous component α_0 and a portion of past income: α_1, α_2 and α_3 are propensities to consume that vary across agents. (2.17) represents the current consumption out of wealth. The consumption function c is the sum of c_{inc} and c_{wea} as in (2.18). What is not consumed is saved (dm_h) as in (2.19), and accumulated to the stock of deposits as in (2.20):

$$dm_{h,i} = ydh_i - c_i \tag{2.19}$$

$$m_{h,i} = \begin{cases} m_{h,-1,i} + dm_{h,i} - q \cdot m_{h,t-1,i} & \text{if} \quad i = e \\ m_{h,-1,i} + dm_{h,i} & \text{if} \quad i = w \end{cases} \tag{2.20}$$

The term $q \cdot m_{h,t-1,e}$ denotes the amount of retained earnings each entrepreneur devolve to

[10] $i = e$ for capitalists; $i = w$ for workers.

fund her investment projects.

2.4.5 Innovation dynamics

Innovation is affected by uncertainty. Potential innovators do not know whether their effort and expenditures to promote technological improvements will succeed or not. A well established evolutionary tradition models firms' innovative activity as a two-step stochastic process (Dosi and Nelson, 2010; Nelson and Winter, 1982)). Although I imagine innovation as it took place with the hiring of researchers, I depart from that tradition for two reasons: firstly, I want to keep the model as simple as possible; secondly, I want to respect some empirical regularity in the innovation process.

To begin, I denote with a_{jj} the labour productivity of the j^{th} firm as result of its effort in R&D, with a_{ji} the labour productivity of the j^{th} firm as result of the imitation process, and a_j the effective labour productivity of the j^{th} firm at some point in time, that is equal to the maximum between a_{jj} and a_{ji}. For simplicity, I assume their equality at the very beginning of the analysis, precisely $a_j = a_{jj} = a_{ji} = 1$. Firms incur new loans to improve their technology levels. The literature often emphasizes the R&D expenditure as share of output as the determinant for the growth in productivity or for the innovation rate in the economy. In this contribution, however, I want to stress the role of the total amount of funds invested on innovative research. In fact, two firms may devolve the exact share but if the absolute amount differs, the larger firm will have higher probability to innovate than the smaller one.[11] The more a firm invests on innovative activities, the more probable it innovates. To represent this process, I can define a logistic probability distribution as an increasing function of the amount invested in R&D:[12]

$$\lambda_j = \frac{1}{1 + \exp^{-\varepsilon \cdot \Sigma_{i=0}^{t} i_{rd,j}}} \tag{2.21}$$

(2.21) is the probability to innovate and it is a sinusoidal function approaching to 1 as $\Sigma_{i=0}^{t} i_{rd,j} \to \infty$. In other terms, the speed with which it tends to 1 is governed by the cumulative amount of resources invested in research and development. It means that the probability each firm has to innovate strictly depends on how much the same firm spends on average. The logistic function has been used quite often in the literature to illustrate the progress of

[11] Think about the comparison between a large firm as Apple and a much smaller one. Suppose both of them invest twenty percent of profits, but for Apple this share amounts to million dollars. For the smaller one, it can amount to thousand dollars only, at best. Who will be the most probable innovator in the field?

[12] Since there are several probability distributions that may do it for us, I tried an *inverse* exponential function and the Gumbel probability distribution. Results do not change significantly.

creation and diffusion of an innovation through its life cycle.[13] Precisely, the introduction of new products or processes in the economies spurs an intense amount of research and development leading to strong improvements in cost reduction and quality. The mid-term outcome consists of a rapid growth of that industry. Clear examples from the past are railroads, urban electrification, cars, light bulbs and so on. However, once those improvements exhausted, new products or processes are so widespread that markets saturate. Back to (2.21), it is important to underline that λ changes from firm to firm, pointing that the ability and probability to introduce innovations are a direct function of the own R&D effort; that peculiarity is tantamount to introduce path dependency and irreversibility in the model.
To know whether innovation occurs, every firm is assigned a random number drawn from a uniform distribution, $p_{inn} = \zeta_1$, in which $\zeta_1 \sim U[0;1]$. If this number is smaller than the threshold λ, the firm innovates. Innovation takes place in the economy as an improvement in labour productivity. Recalling the model focuses on levels and not on growth, labour productivity is a direct function of the average outlay in innovation activities:

$$a_{jj} = a_0 + a_1 \cdot i_{rd,av,j} \tag{2.22}$$

in this way I take into account firm's ability to learn from past achievements.

The imitation process is similar to the innovative one. Let us look at firms as if they were people walking in the street. The single person has got a certain probability to meet somebody. For simplicity, one person cannot meet more than three people in the same period. Moreover, meetings are fully random. I can image each meeting as the single possibility to copy the technology of the competitor. The imitation process occurs with the same law followed by the innovation process. Individuals make use of only local knowledge and make transaction with positive probability as long as it is beneficial to them. To formalize it, I define a $F \times F$ network matrix, called imi_{net}. Its cells take value 1 if a connection between two firms is established, and 0 otherwise. Once I got all the linkages, I record in a_{ji} all the potential productivity levels that a firm can reach by imitating the technology of its competitors. Then, the firm compares the productivity levels from imitation and home-innovation, choosing the best-performing technique and updating its productivity. As before, every firm is assigned a number drawn from a uniform distribution, $p_{imi} = \zeta_2$, which is compared to the λ threshold

[13] De Tarde (1903) was the first.

above. This represents an important feature of the model: the probability the firm has to imitate strictly depends on its amount of innovative investments. In other terms, I do exclude *free-rider* or opportunistic behaviours. Therefore, if $p_{imi} < \lambda$ a firm may imitate when $i_{rd} > 0$. Then:

$$a_j = max\left[a_{jj}; a_{ji}\right] \tag{2.23}$$

2.4.6 Banking system

Schumpeter (1934) places the banking system side by side with the creative entrepreneur, as is the case of a symbiotic relationship. The former makes innovative investments possible through the opening of a credit line for the necessary expenditures, while at the same time the banker is offered a possibility to earn money by the innovative businessman.
In reality banks discriminate between clients according to their credit worthiness by credit rationing. In the AB literature, it is quite common to assume banks discriminate through higher or lower interest rates on loans. Since I am not very concerned to banks' behaviours in financial markets, I follow Deissenberg et al. (2008) in which the banking sector is composed of an aggregate bank and constitutes a pure accommodating agent. It provides production firms with loans to finance their investment plans and gathers whatever amount of deposits the public wishes to hold. For simplicity, households' accumulated wealth takes the form of bank-account deposits only. For the same reason above, the big bank sets constant interest rates: it funds loans at a rate r_l and rewards deposits with a rate r_h. Obviously, $r_l > r_h$ strictly holds. The equations describing the bank's behaviour are the following:

$$int_{ld,j} = r_l \cdot \sigma_{ld,j} \cdot L_{d,t-1} \tag{2.24}$$

$$int_{mh,j} = r_h \cdot \sigma_{mh,j} \cdot M_{h,t-1} \tag{2.25}$$

$$F_{b,t} = r_l \cdot L_{d,t-1} - r_h \cdot M_{h,t-1} \tag{2.26}$$

(2.24) describes the interest payments the bank picks from each firm according to its share on total loans, $\sigma_{ld} \cdot L_{d,t-1}$.[14] (2.25) reflects how the bank rewards the single household's deposit, according the its share on total wealth, $\sigma_{mh} \cdot M_{h,t-1}$. (2.26) is the banking profits equation. To

[14]In which $\sigma_{ld} = \frac{l_d}{L_{d,t}}$; $L_{d,t}$ is the aggregate amount of loans.

ensure consistency, bank's profits are distributed to households as in (2.15).

2.4.7 Prices, mark-up and inflation expectations

The model does not involve the production of public goods, hence the prices we should consider come from the unit price of private output. Firms set the price as a mark-up over unit labour costs:

$$p_j = (1 + \mu_j) \cdot \frac{w_r}{a_j} \tag{2.27}$$

Entrepreneurs set the mark-up according to the market-share *differential*:

$$\mu_j = \mu_0 + v \cdot (\sigma_{m,t-1,j} - \bar{\sigma}) \tag{2.28}$$

where μ_0 and v are constant while $(\sigma_{m,t-1,j} - \bar{\sigma})$ indicates that the mark-up increases when the market share is above the median market share and decreases in the opposite case. The market share will be determined accordingly:[15]

$$\sigma_{m,j} = \frac{y_j}{Y_t} \tag{2.29}$$

The inflation rate is the percentage change in the average price level and it is obtained once average prices are computed:

$$\bar{P} = \frac{1}{F} \Sigma_j^F p_j \tag{2.30}$$

$$\Pi_t = \frac{\bar{P}_t}{\bar{P}_{t-1}} - 1 \tag{2.31}$$

Inflation enters the model through its influences on investment and consumption decisions. I adopt a *regressive* inflation-expectations process since it "[...] provides a more accurate approximation of how economic agents make their decisions in the real world" (Sawyer and Passarella, 2019, p. 13). I define the expected inflation rate Π^e as:

$$\Pi^e = \psi_0 + \psi_1 \cdot \left(\Pi^T - \Pi_{t-1}\right) + \Pi_{t-1} \tag{2.32}$$

where Π^T is the target inflation rate while ψ_0 and ψ_1 are parameters. The expected price level P^e is:

$$P_t^e = (1 + \Pi^e) \cdot \bar{P}_{t-1} \tag{2.33}$$

[15] Y_t is aggregate production.

The final step consists of introducing the following term into the target-capital and wages functions, defined as the ratio between expected and actual prices:

$$PR_t = \frac{P_t^e}{\bar{P}_t} \tag{2.34}$$

2.5 Notes on the baseline model

The model is run through 450 periods on quarterly basis. It does not allow for analytical, closed-form solutions. The latter is a general characteristic of AB models and comes from the many non-linearities in the agent decision rules and patterns of interaction. Most coefficients and initial values of variables are either borrowed from the literature or given reasonable values. For instance, each firm is endowed with a single unit of (capital) good in the first period of the simulation. The symmetry condition is borrowed from Caiani et al. (2016b). However, key coefficients of key behavioural equations are given stochastic values varying across agents. Examples are the marginal propensities to consume out of income, the coefficient in the R&D investment function and so on. Tab. 2.7 clarifies which parameter varies and which does not. It is important to underline that the symmetric condition of agents' initial characteristics does not prevent that heterogeneity emerges in subsequent stages of the model, as outcome of interactions among agents. The adoption of stock-flow norms since the very beginning dampens the arbitrariness of behavioural parameters and influences from purely stochastic factors. At the same time, I perform 100 Monte Carlo runs to wash away the variability across simulations. As clarified by (Dosi et al., 2010, p. 1755): "Monte Carlo distributions are sufficiently symmetric and unimodal to justify the use of across-run averages as meaningful synthetic indicators". The use of Monte Carlo averages might none the less be problematic according to the model: in a case of quasi-deterministic models it is likely that the evolution of the economy is similar in multiple simulations, whereas more erratic models can exhibit cycles in different periods of the simulation. In the second case, averaging Monte Carlo runs and assessing the results of the simulations based on the mean and confidence intervals can be misleading. The risk is to averaging out interesting phenomena which are only detectable when the dynamics of each simulation is analyzed. A scrupulous study of single simulations in Fig. 2.4 reveals however that such case is not a major problem in the present setting.[16]

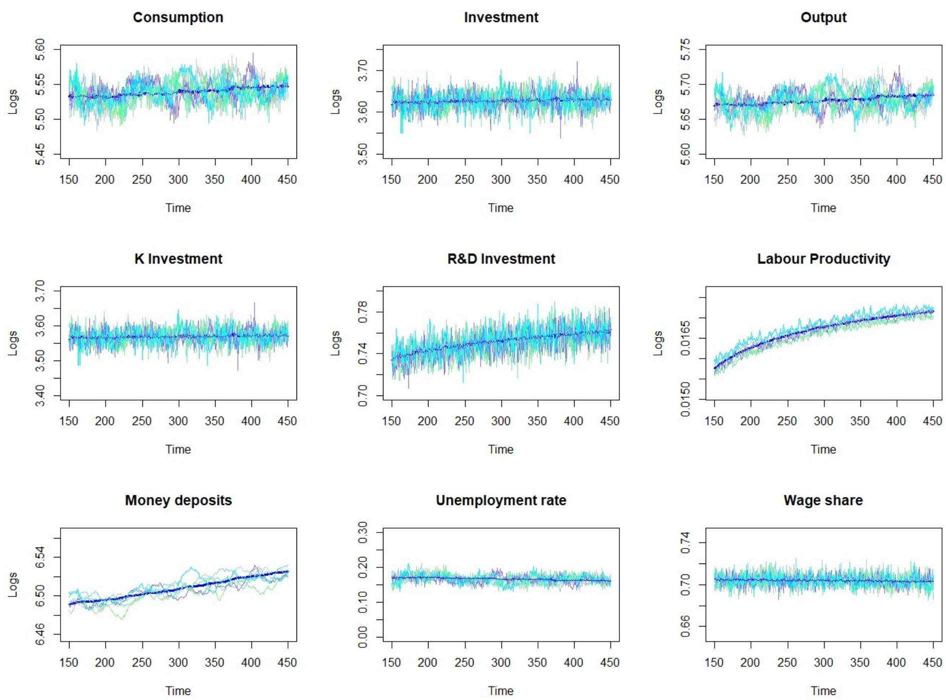
Fig. 2.5 displays average trends surrounded by their standard deviations for the main variables of interest. The figure shows that the model first experiences the usual *burn-in* period,

[16] I thank Alberto Russo for the warning about such potential matter.

Notation	Description	Value
$Time$	Time span	450
MC	Monte Carlo runs	100
F	Firms	90
N_s	Workers-Consumers	400
α_0	Autonomous consumption	0.001
α_1	Worker's marginal propensity to consume out of income	[0.75; 0.9]
α_2	Capitalist's marginal propensity to consume out of income	[0.5; 0.7]
α_3	Marginal propensity to consume out of wealth	[0; 0.1]
a_0	Labour-productivity initial value	1
a_1	Coefficient in the productivity equation	0.75
δ	Capital depreciation	0.05
ε	Parameter in the threshold function	0.05
φ	Inverse normal capital-output ratio	1
i_0	Autonomous investment	0.8
i_1	Partial-adjustment coefficient	[0.15; 0.2]
μ_0	Coefficient in the mark-up equation	0.075
$meet$	Meetings per unit of time	5
ψ_0	Coefficient in the price expectations function	0
ψ_1	Coefficient in the price expectations function	0.01
q	Share of capitalist wealth re-invested	0.0023
ϱ	Normal profit rate	0.05
r_l	Interest rate on loans	0.0075
r_h	Interest rate on deposits	0.0025
ϑ_0	Coefficient in the R&D investment function	0.005
ϑ_1	Coefficient in the R&D investment function	0.005
v	Coefficient in the mark-up function	0.02
w_0	Coefficient in the wage equation	0.625
w_1	Coefficient in the wage equation	0.05
ζ_1	Stochastic component from a uniform distribution	[0; 1]

Note: shaded lines denote variables whose value differs between agents.

Table 2.7. Parameter setting for the stationary-state model



Note: Thick lines are Monte Carlo averages.

Figure 2.4. Baseline model: single Monte Carlo runs

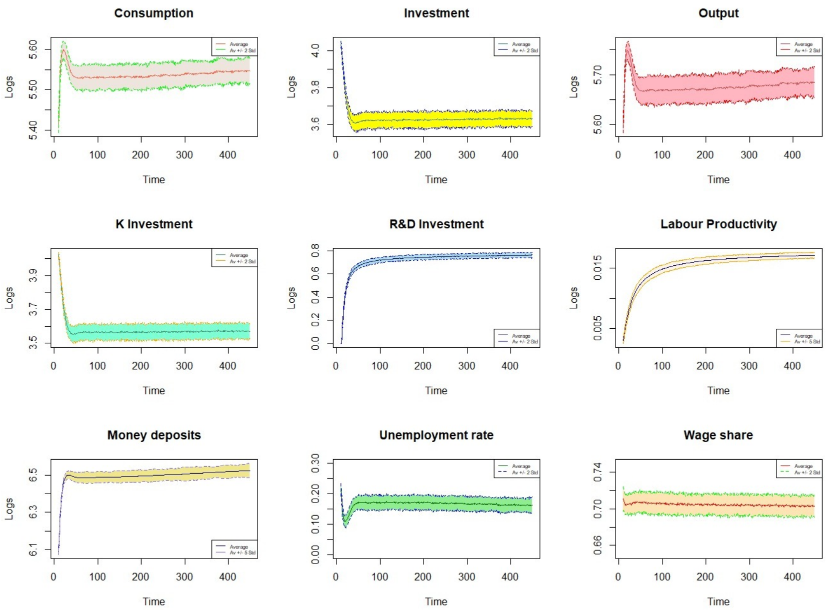


Figure 2.5. Baseline model: levels in log terms

converging to a relatively stable configuration after 30 periods circa. I call this situation a *stationary state*. However, convergence toward a stationary state does not imply *stasis*: a roller-coaster dynamics generates persistent fluctuations at the business-cycle frequencies. This is confirmed also by the amplitude of standard-deviation intervals around the average trend. [17] In addition to this, the model is stock-flow consistent as plotted in Fig. 2.6: the adoption of stock-flow consistency norms since the very onset diminishes the arbitrariness of behavioural parameters and the influences from purely stochastic factors.

Output, consumption and the unemployment rate exhibit a unit root, so they are nonstationary: that can be ascertained through Tab. 2.8 in which I applied either the ADF or the KPSS test for unit roots. By contrast there is uncertainty for aggregate investments: the ADF test does not find a unit root in the time series, but the KPSS does. In general, these results confirm the existence of a persistent and significant auto-correlation between the value assumed by a series at time t and its preceding values.[18]
Fig. 2.7 compares the volatility structure of main aggregate variables through a comparison of their cyclical components. I have separated trends and cyclical components using the Hodrick-Prescott filter. However, I am well aware that assuming trends and cycles as *additive*

[17] A common practise in AB models is that of doing away the initial periods of the simulations. They concern to the transient phase before convergence and they are strongly affected by initial conditions. I nonetheless display also those periods for completeness of exposition and for the reasons in Caiani et al. (2016a).
[18] I do not report auto-correlation plots for brevity reasons: they are available upon request.

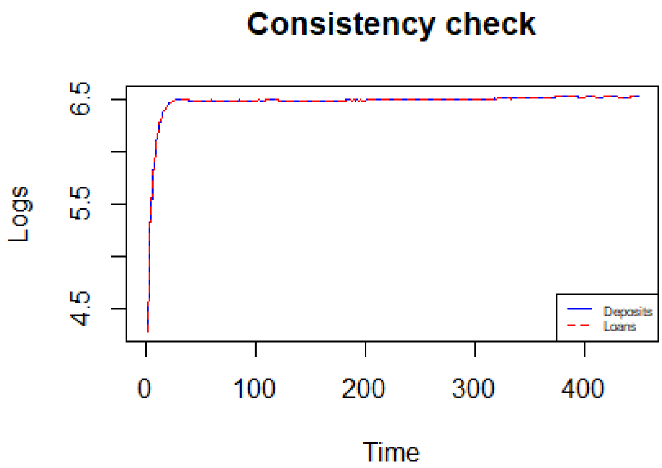


Figure 2.6. Consistency check

	ADF test	KPSS test
Output	−1.7895	2.1682
	(0.3855)	(0.739)
Consumption	−1.5761	2.1783
	(0.4938)	(0.739)
Investment	−6.9708	1.6494
	(0.000)	(0.739)
Unemployment rate	−1.7992	2.1657
	(0.3807)	(0.739)

Note: ADF test assumes unit root in the null hypothesis, while the KPSS test supposes time-series are stationary. I deleted the first one hundred period simulations to focus entirely on the stationary state.

Table 2.8. Unit root test on selected aggregate variables

is a very simplifying hypothesis. Furthermore I normalized the cyclical component by the trend to allow for a comparison on same scales. The artificial time series replicate well-known empirical evidence such as in Napoletano et al. (2006) and Fagiolo et al. (2008). In particular, investment components and the unemployment rate are indeed more volatile than output and consumption, while the latter is almost as volatile as output. Consumption should actually be a bit less volatile than output. This is not very clear in the model probably due to my assumption about consumption functions.

Fig. 2.8 captures the cross-correlation function of the previous variables with respect to aggregate production. In tune with the literature, consumption and aggregate investments are pro-cyclical and lead output. Productivity displays a clearly pro-cyclical and slightly leading

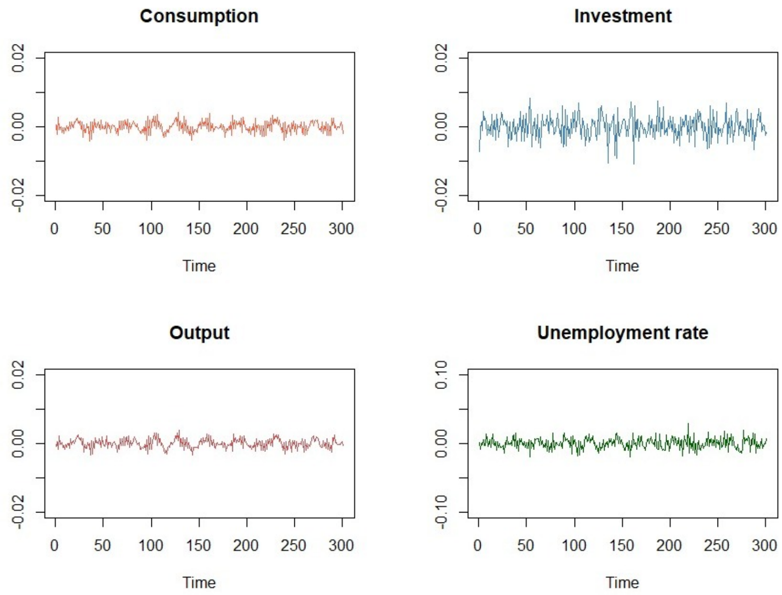
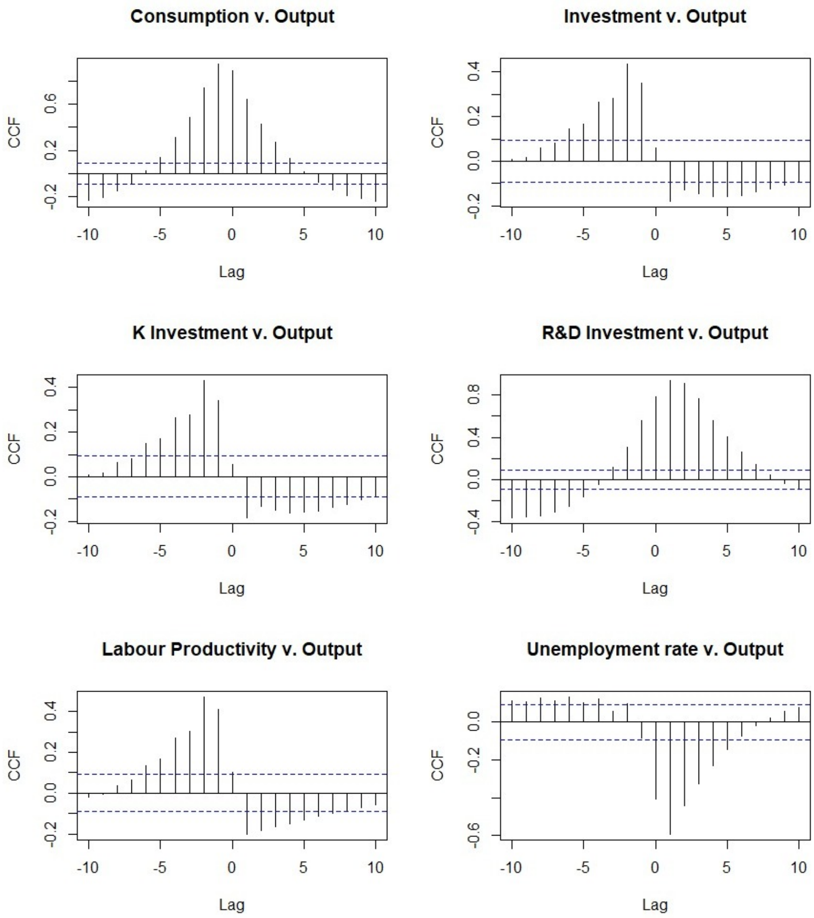


Figure 2.7. Cyclical components of simulated time series

pattern while unemployment is counter-cyclical and lagging. I have to spend nonetheless some words on the investments' behaviour at micro-economic level. There is an important body of literature showing that investment decisions are dictated by an opportunity-cost effect: if firms experience a sales boom and in the absence of tight credit constraints, they prefer allocating their human and physical assets to current production. Hence, longer-term (innovative) investments should be counter-cyclical, while short-term investments are pro-cyclical.[19] However, Napoletano et al. (2006) found empirical evidence that aggregate investments are pro-cyclical and synchronized with – or slightly leading – the business cycle. My model does not explicit any remarkable trade-off between short-term or long-term investments or between investments in tangible and intangible assets. Additionally, I do not model any particular credit-market constraint. So, my results are consistent with either Napoletano et al. (2006), Dosi et al. (2018) and Wälde and Woitek (2004), since R&D investments are pro-cyclical. Anyhow, the debate is still open and deserves further attention in future research.

Beside these macroeconomic stylized facts, the model is able to replicate micro- and meso-economic empirical evidence. First of all, I have properties about firms size distribution. The literature on the topic says that manufacturing industries are characterized by skewness and heavy-tailedness in firms distribution (Bottazzi and Secchi, 2003, 2006). I consider three proxies

[19] In contrast, the huge presence of credit constraints makes long-term investments pro-cyclical. For further detail, see Aghion et al. (2010, 2012), Chiao (2001) and Rafferty and Funk* (2004).



Note: Dashed lines in the plots indicate statistical significance.

Figure 2.8. Baseline model: cross-correlations with respect to aggregate output

for size: sales of consumption commodities, production of either consumption and capital goods, and the employment level. The threefold choice helps me to gain some robustness in the results. Fig. 2.9 shows an interesting outcome: my proxies can be perfectly fitted by a gamma probability distribution, which is right-skewed and presents a tail heavier than normal distribution. The model leads to a configuration in which the economy is populated by many small firms and few big enterprises.[20]

Bottazzi and Secchi (2003) deal with moments of firm size too; they argue that moments are generally stationary and trendless, with some exception about the mean. Tab. 2.9 and Fig. 2.10 display my findings. Although moments are clearly stationary according to the standard ADF test, I cannot express a uniform opinion about trends. Precisely, there is no doubt about the trendless-ness of skewness and kurtosis for each proxy of firm size; however, either the means or the standard deviations seem to exhibit a significant trend, a trend which is positive for employment while negative for production and sales. I have to remark that, albeit statistically significant, the corresponding magnitude is very tiny.

A further feature out of the model is the heterogeneity in productivity that distinguishes our firms, as we may appreciate from Fig. 2.11. I am not able to provide a good probability distribution for productivity differentials; nevertheless, it is clear that heretogeneity takes the form of high skewness with the right tail heavier than in the normal distribution case. Bartelsman and Doms (2000) claim that productivity levels are quite dispersed and differentials reflect the differences in the outcomes of technological bets: even if the entrepreneurs bet the same, they may not reap the same rewards because of uncertainty.

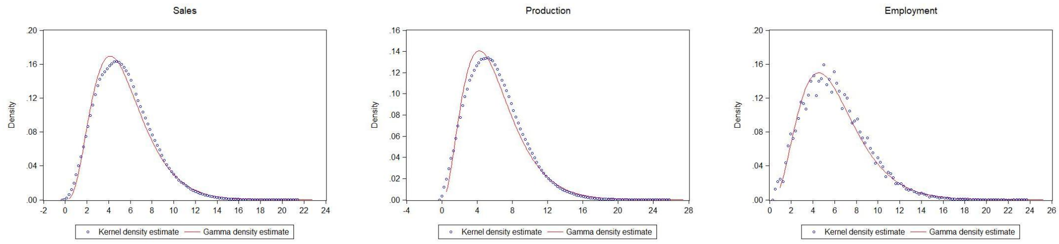
Finally, investments are heterogenous and possibly lumpy as in Figs. 2.12 and 2.13, i.e. firms do experience investment spikes and co-exist with near-zero investment firms (Dosi et al., 2010). Abundant literature shows that investments in manufacturing is characterized by periods of intense activity interspersed with periods of much lower one (Caballero, 1999; Doms and Dunne, 1998). However, I should remark that lumpiness has been modeled in economics through (S, s) investment functions. This family of schedules displays discontinuities not visible with linear investment functions as mine. So, if my framework gets lumpiness, it arises out of two main determinants: the matching process between firms and consumers, and the process of creation and diffusion of innovations. Such mechanisms allow for discontinuities in the demand each firm faces, so they affect investment patterns leading to high-investment

[20] We will see in Part II that economic growth let firm size move from a gamma toward a log-normal distribution, which looks more skewed and heavier-tailed. Additionally, the latter is in line with the shapes described by Bottazzi and Secchi (2003).

	Sales		Production		Employment	
	Trend β	ADF test	Trend β	ADF test	Trend β	ADF test
Mean	$-6.80E-05^{*}$	-8.1309^{***}	-0.0001^{***}	-17.8379^{***}	0.0007^{***}	-11.4832^{***}
Standard deviation	-0.0003^{***}	-14.7695^{***}	-0.0005^{***}	-17.27723^{***}	$-2.50E-05$	-6.4327^{***}
Skewness	-0.0001	-19.7903^{***}	-0.0001	-19.5577^{***}	-0.0001	-20.4145^{***}
Kurtosis	0.0003	-12.6002^{***}	$7.17E-05$	-19.0745^{***}	$5.45E-05$	-19.3862^{***}

Note: moments are computed after $t = 100$, so when the model already gravitates around the stationary state. ADF test assumes unit root in the null hypothesis, while the KPSS test supposes tie-series are stationary. Star significance: $^{***}p < 0.01$, $^{**}p < 0.05$ and $^{*}p < 0.1$.

Table 2.9. Moments of firms size distribution

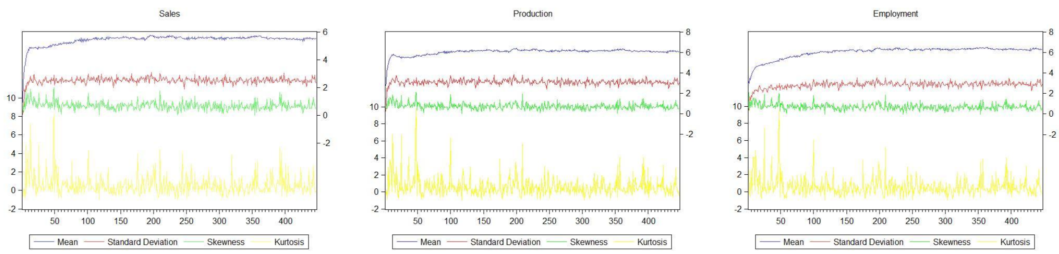


Note: sales refer to shipments of consumption good, while production is about shipments of consumption and investment goods.

Figure 2.9. Firm size distribution

periods followed by a longer calm.

To conclude this Section, Tab. 2.10 reports to the wide spectrum of real stylized facts matched by the model. I point again that my firm-level analysis has been possible through the adoption of the AB procedure. Standard macro-models, for instance, do not allow for such a deepening. Furthermore, the empirical validation gives robustness to my policy experiments. The outcomes I get suggest as the observed correlation structures are not simply dependent on specific parametrizations of the model: as explained by Caiani et al. (2016a), if I changed the parameters of the model, I would obviously get differences in the behaviour of the agents and



Note: sales refer to shipments of consumption good, while production is about shipments of consumption and investment goods.

Figure 2.10. Moments of size distribution

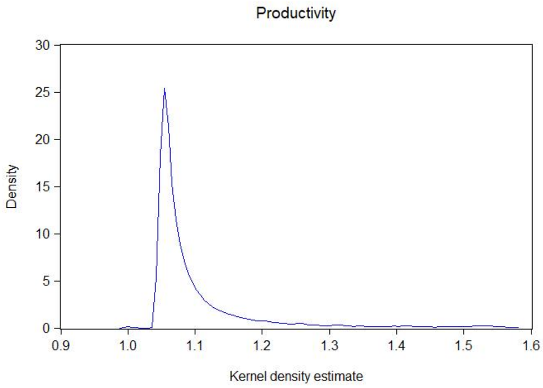


Figure 2.11. Productivity differentials at firm level

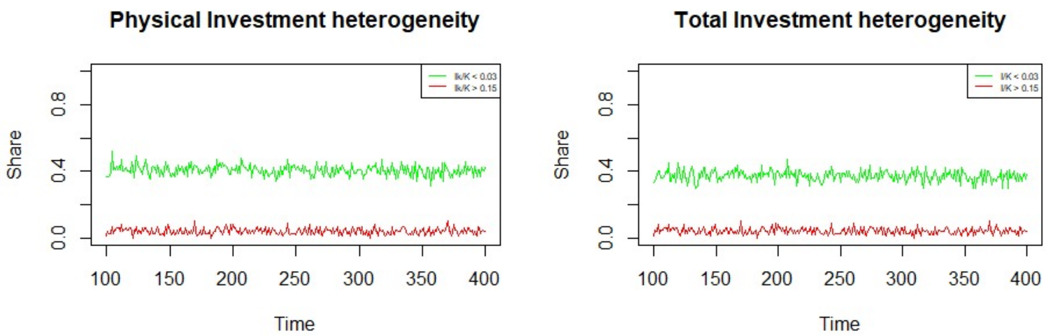
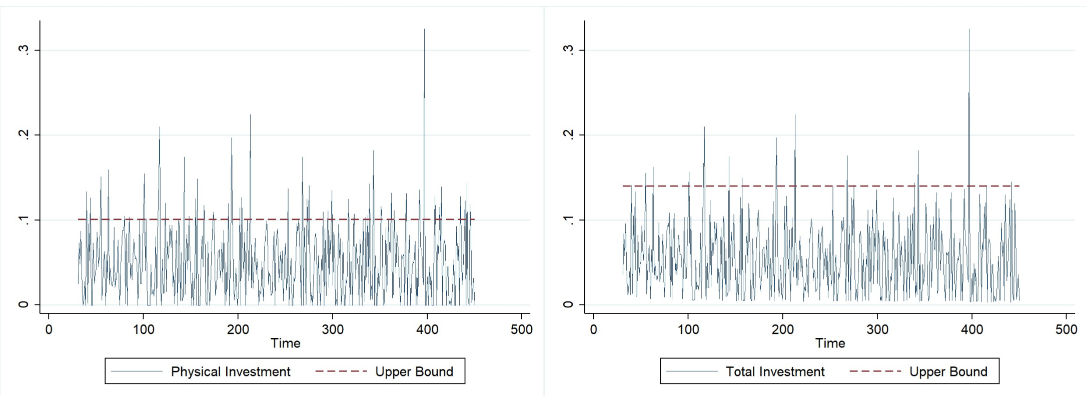


Figure 2.12. Investment heterogeneity at firm level



Note: investment patterns from a selected firm; the upper bound is determined as median value plus one standard deviation.

Figure 2.13. Investment lumpiness?

Stylized facts	Tables - Figures	References
Micro-economic level (firms)		
Skewness and heavy tailed-ness firm size distribution	Fig. 2.9	Bottazzi and Secchi (2003, 2006)
Moments of size distribution are stationary	Tab. 2.9, Fig. 2.10	Bottazzi and Secchi (2003); Dosi et al. (2010)
Heterogeneous productivity across firms	Fig. 2.11	Bartelsman and Doms (2000); Bottazzi and Secchi (2003)
Investment heterogeneity and lumpiness	Figs. 2.12- 2.13	Caballero (1999); Doms and Dunne (1998)
Macro-economic level (aggregate)		
Fluctuations at business-cycle level	Fig. 2.5	Caiani et al. (2016a); Stock and Watson (1999)
Stock-flow consistency	Fig. 2.6	Godley and Lavoie (2006)
Output components and unemployment are non-stationary series	Tab. 2.8	Blanchard and Summers (1986); Hamilton (2020); Nelson and Plosser (1982)
Volatility of output, investment, consumption and unemployment	Fig. 2.7	Stock and Watson (1999)
Cross-correlations among macro-variables	Figs. 2.8	Stock and Watson (1999)
R&D cyclicality	Figs. 2.8	Wälde and Woitek (2004)

Table 2.10. Stylized facts matched by the stationary-state model.

consequently aggregate results would differ; however, the inherent properties of the model in term of correlation structure and the way variables impact on each other would be the same and not tied to a specific set of parameters.

2.6 Policy experiments

Once the model approaches to the stationary state, I carry out some policy experiments. I modify the value of some parameter or exogenous variable to see how the economy reacts and then compare the different stationary states. I test a variety of values for the coefficients of the wage equation w_0 and w_1, the interest rate on loans r_l, the meetings per unit of time *meet* and for the parameter in the λ function, ε. The first and the third policies are the most important, since they concern to the role played by the functional distribution of income and the interest rate. The second helps check if the model works as expected and helps me confirm previous results. Finally, the last two are about an enlargement of innovation and imitation possibilities.

2.6.1 The role of income distribution

The reason to test the role exerted by wages lies in the general disagreement found in the literature (Onaran and Galanis, 2012; Stockhammer, 2017). On the one hand, some argue that high wages squeeze profits and reduce investments, while keeping them in check frees resources and helps increase output and employment. On the other hand, high wages foster aggregate demand, enhancing investment outlets and providing incentive for a dynamic mechanization of the productive process. Positive effects are then reflected by higher profits.

The parameter w_0 is as the balance of the social conflict between workers and entrepreneurs in the economy as a whole. In contrast, w_1 allows for the endogenization of the wage rate and represents the influence exerted by past unemployment dynamics. Fig. 2.14 displays several scenarios representing social compromises more, or less, favourable to capitalists. They result in lower, or higher, values for the parameter w_0, respectively. Lower wages result in worse economic performances. Wages indeed sustain consumption and, indirectly, investments. A lower aggregate demand reduces capitalist's incentive to invest either on capital stock or on innovation activity at the micro-economic level. The reason lies in the fact that firms try to adjust the capital stock to reach a normal capital-output ratio as in (2.2). If target output declines, so does target capital and firms start disinvesting. On the same line, the decrease in sales does not provide the incentive to perform R&D and save labour. Firms will find more convenient to adapt the productive process to less labour-saving techniques. The result will be a worse general economic performance on aggregate. For what concerns to R&D investments, the negative effect of decreasing wages is not fully counterbalanced by the increase in the profit rate, which provides the entrepreneurs with an incentive to undertake innovative investments as in (2.6). If the discrepancy between the actual and the normal profit rate were sufficiently large, a distribution of income more favourable to capitalists would have resulted in a better economic performance, with higher employment and income levels the lower w_0. However, the negative effect of low wages more than compensates that *positive* effect.

Results are less clear in Fig. 2.15 with different values of w_1: as in (2.13), it accounts for the negative influences of unemployment dynamics on the wage rate. The picture reveals that different values of w_1 do not affect in a sensible way the pattern of capital investment. For what regards the other variables, lower values of w_1 lead to higher absolute levels for consumption, output and R&D activity, along with lower unemployment rates. I have nonetheless to admit that rising performances are (weakly) distinguishable only after a certain level assumed by w_1, for instance the value signaled by the blue line. I ascertain from what said that either the impact of a change in w_1 is very tiny in absolute levels or that the same impact looks straightforward only once a given *threshold* is reached, paving the floor to non-linear effects on my variables of interest.

In conclusion, I trace out from the first set of policy experiments the positive influence of higher wages in triggering a process of economic development and innovation achievements. To put things differently, the improvement of labour market regulation, the centralization of the industrial relation system or other pro-worker measures help achieve better results in terms of long-run performances, such as lower unemployment rates or higher capital accumulation and productivity. This belief is line with Allen (2009, 2011) and Dosi et al. (2018).

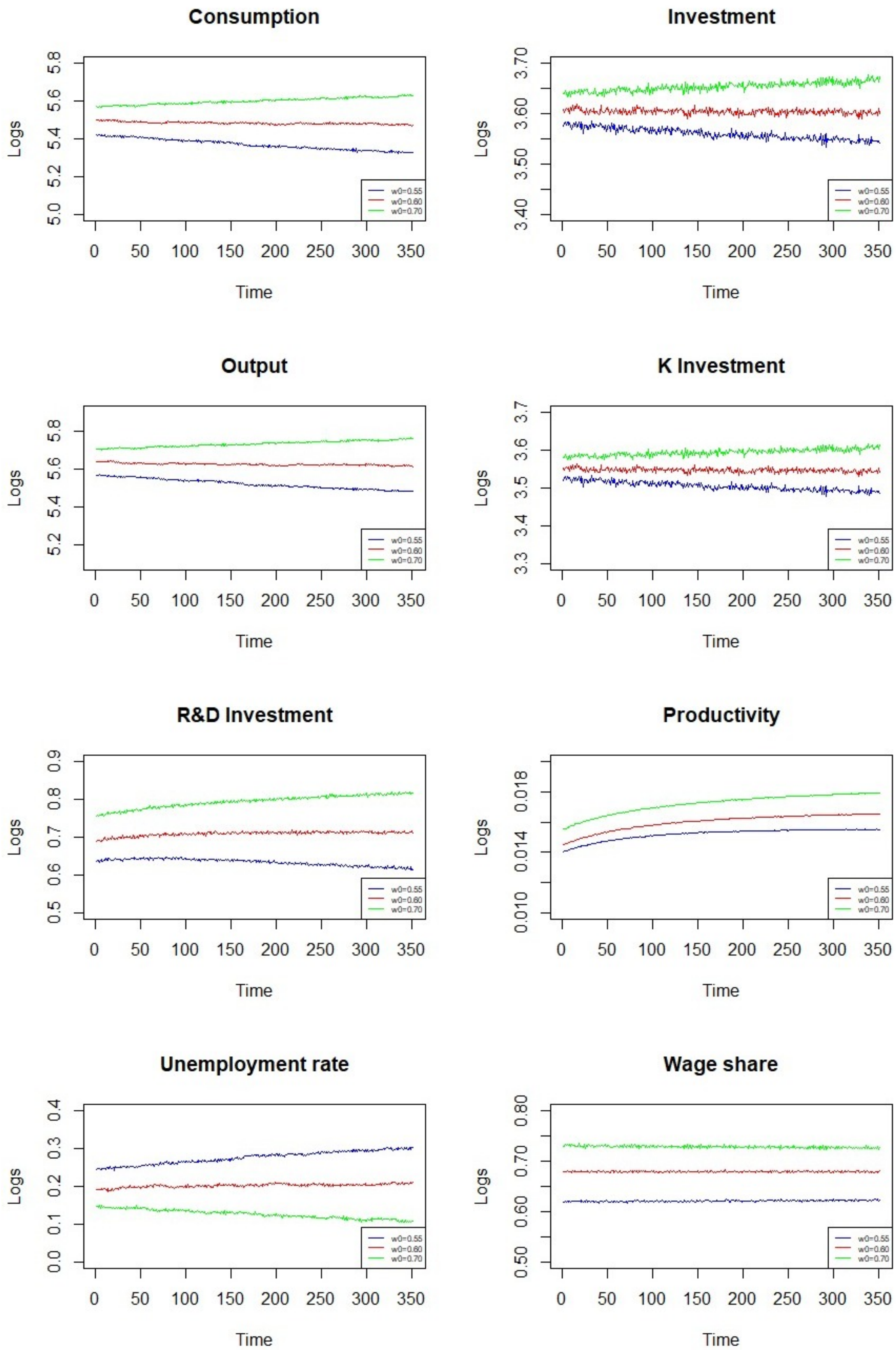


Figure 2.14. Policy experiment on w_0

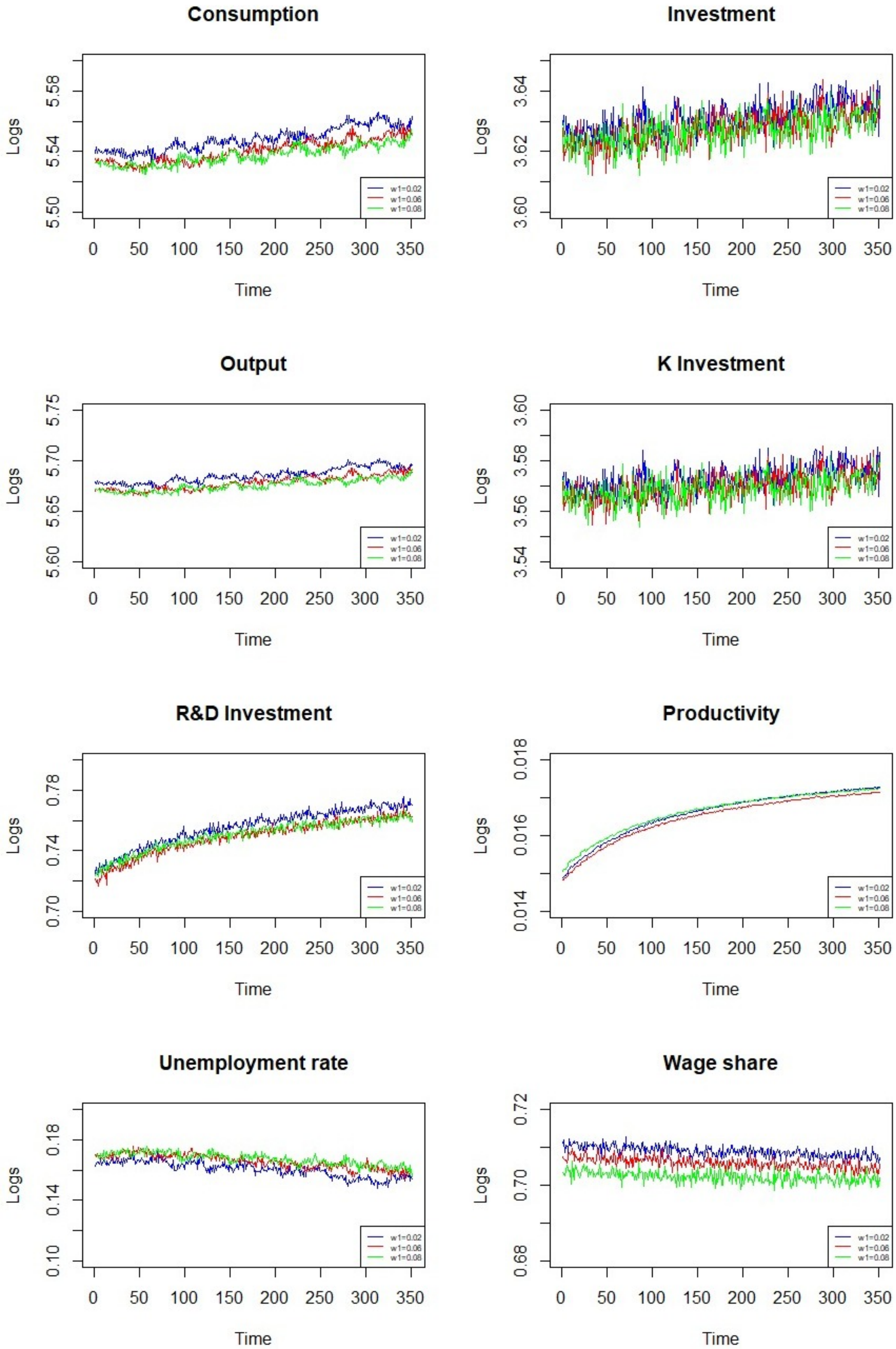


Figure 2.15. Policy experiment on w_1

2.6.2 The role of interest rates

The economic literature always asked whether, and how, the interest rate spurs the economic activity. The standard neoclassical belief is that a cut in the rate of interest stimulates the expansion of production since capitalists are less burdened by the service of debt. Theoretical arguments in tune with Petri (2004) and Girardi (2016) assume the rate of interests does not directly influence investment decisions. Although I follow this reasoning, there are yet several channels with which the interest rate could affect investments and the economic performance as a whole: the interest rate on loans influences firm's profits, through a lower service of debt as in (2.7) and through restricted banking profits and in (2.26); such influences do in turn impact upon consumption and R&D expenditures. Fig. 2.16 shows the effect of different rates of interest on loans applied to firms, r_l. Lower services of debt increase the amount of profits in capitalists' pockets; this amount translates into higher consumption levels out of capitalist income, which contribute to sustaining aggregate demand. Investments in capital stock and R&D will rise accordingly at the micro-economic levels, since the entrepreneurs will adjust the capital stock to fulfill a higher target capital requirement, on the one hand, and because of the increased discrepancy between actual and normal profit rate, on the other hand. Such positive effects on investment spending and on consumption out of capitalist income overwhelm the corresponding negative impact of lower distributed banking profits upon household consumption. In addition to this, I remark that the *net* positive impact of lower interest rates in terms of production is accompanied by a shrinkage in the share of income going to labour, as outcome of enhanced profits.

2.6.3 Experiments on the innovation possibilities

The last set of experiments consists of loosening the *barriers* to innovation and imitation. The economic theory spent a lot of effort to judge whether the protection of intellectual property rights is a vehicle, or not, for further innovation attainments, coming to heterogeneous conclusions. My simple setting does not allow for very complex analyses, but it could nonetheless provide some insights. I test an increase in the maximum number of meetings per unit of time, *meet*, and an increase of a parameter in the threshold function λ, ε. Both of them may affect the innovation and the imitation rates in the economy, increasing the flow of ideas at the meso-economic level.

Fig. 2.17 is about an increase in the parameter *meet*. I have already described it as the mea-

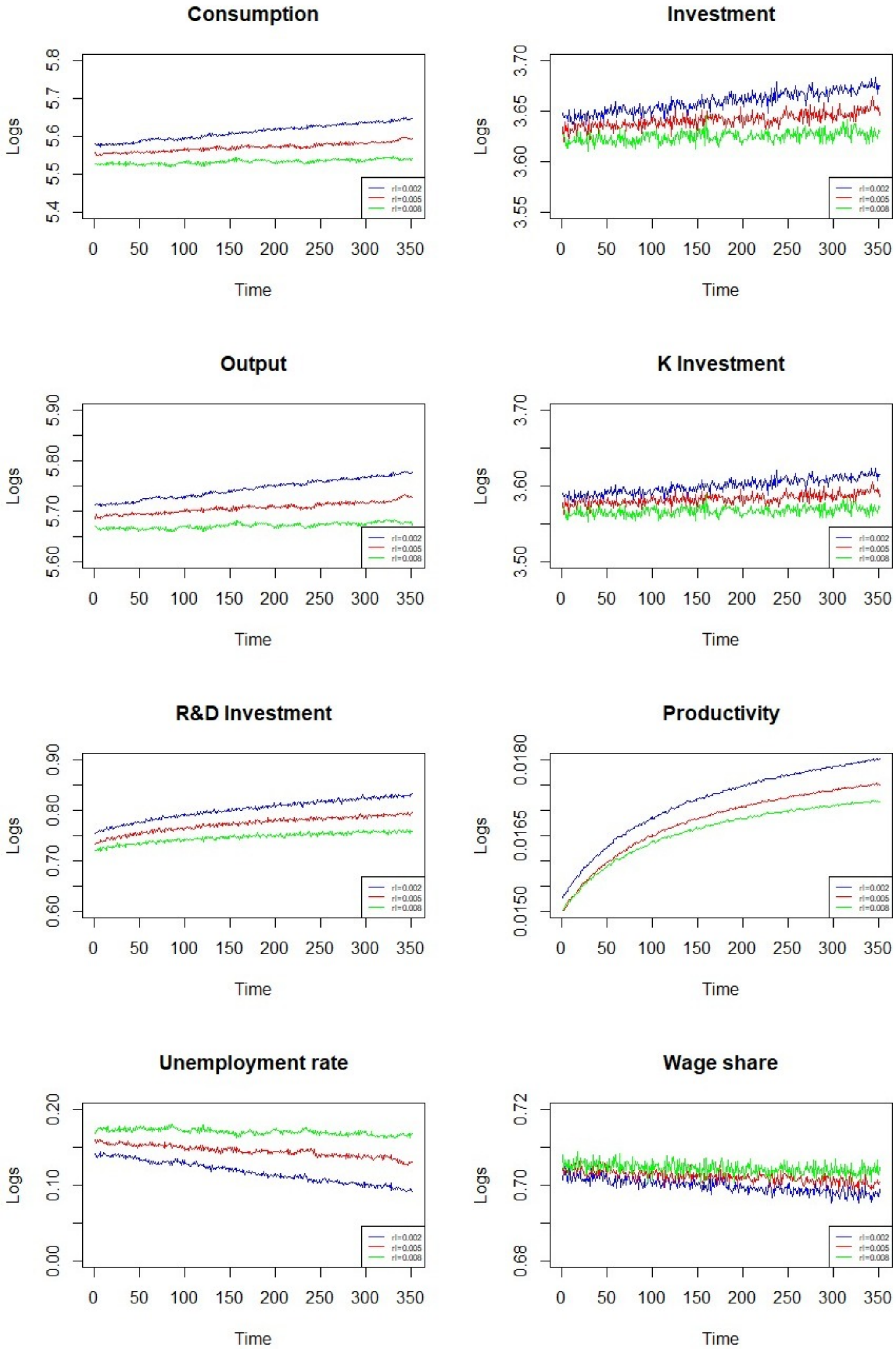


Figure 2.16. Policy experiment on r_l

sure of the network size around the single capitalist. More meetings per unit of time consist of more potential competitors from which to imitate and, at the same time, more exposure toward competitor's imitation. However, the first effect seems prevailing: the higher capability to imitate raises labour productivity at firm level and profits. More profits, more spending out of capitalist income and hence more sales. Further achievements in labour productivity are then possible through (2.21). The new stationary state is higher than the baseline. However, the positive effects are evident in the very long run only, while in the short-to-medium run results are very uncertain, because of the increased volatility around the average trends. Furthermore the impact on unemployment rates, capital investments and wage shares is negligible, if any, in the long term too.

Something similar occurs through a slight increase in ε. (2.21) represents the speed with which the logistic function λ converges to 1. I recall that λ is the probability to innovate and imitate according to the level of R&D outlays. The greater ε, the greater λ, the greater the labour productivity and the firm's profits. The economy gravitates around higher stationary states as in Fig. 2.18. Anyway, the positive outcomes, if any, are circumscribed to the very long period.

2.7 Conclusions

The aim of Part I was to set Secular Stagnation into the agent-based perspective and to provide some insights on the matters affecting the US economy since the end of the Golden Age of capitalism (1950-1973). Crucial features of the American economy are the very remarkable slowdown in growth of federal R&D expenditures and the redirection, by many leading firms, of resources and attention from more exploratory scientific research towards more commercially-oriented projects (Arora et al., 2018). They accompany the mounting retrenchment of the wage share and the decreasing productivity growth noticeable since 1973.

I developed a simple agent-based, stock-flow consistent model for a one-good two-class closed economy without government sector. The distribution of income between wages and profits is pivotal to determine the intensity of R&D activity within the economic system. Though the very simple framework, the model shows that distributions of income more favourable to wages, the improvement of the social protection system, the centralization of the collective bargaining structure or any other pro-labour policy result in better economic performances on aggregate, since production, capital accumulation and labour productivity would gravitate around higher stationary states. The American economy experienced a strong weakening of

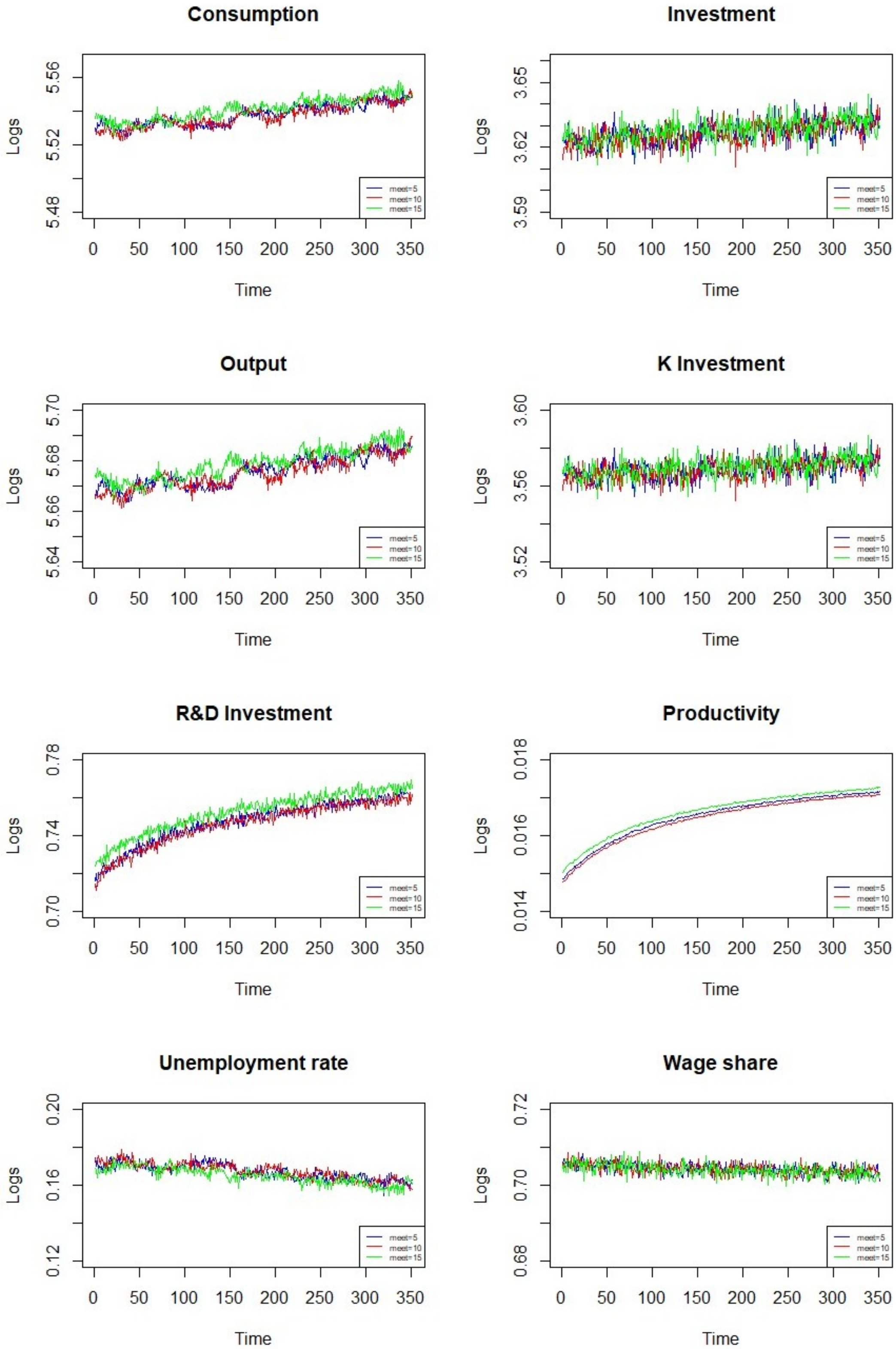


Figure 2.17. Policy experiment on *meet*

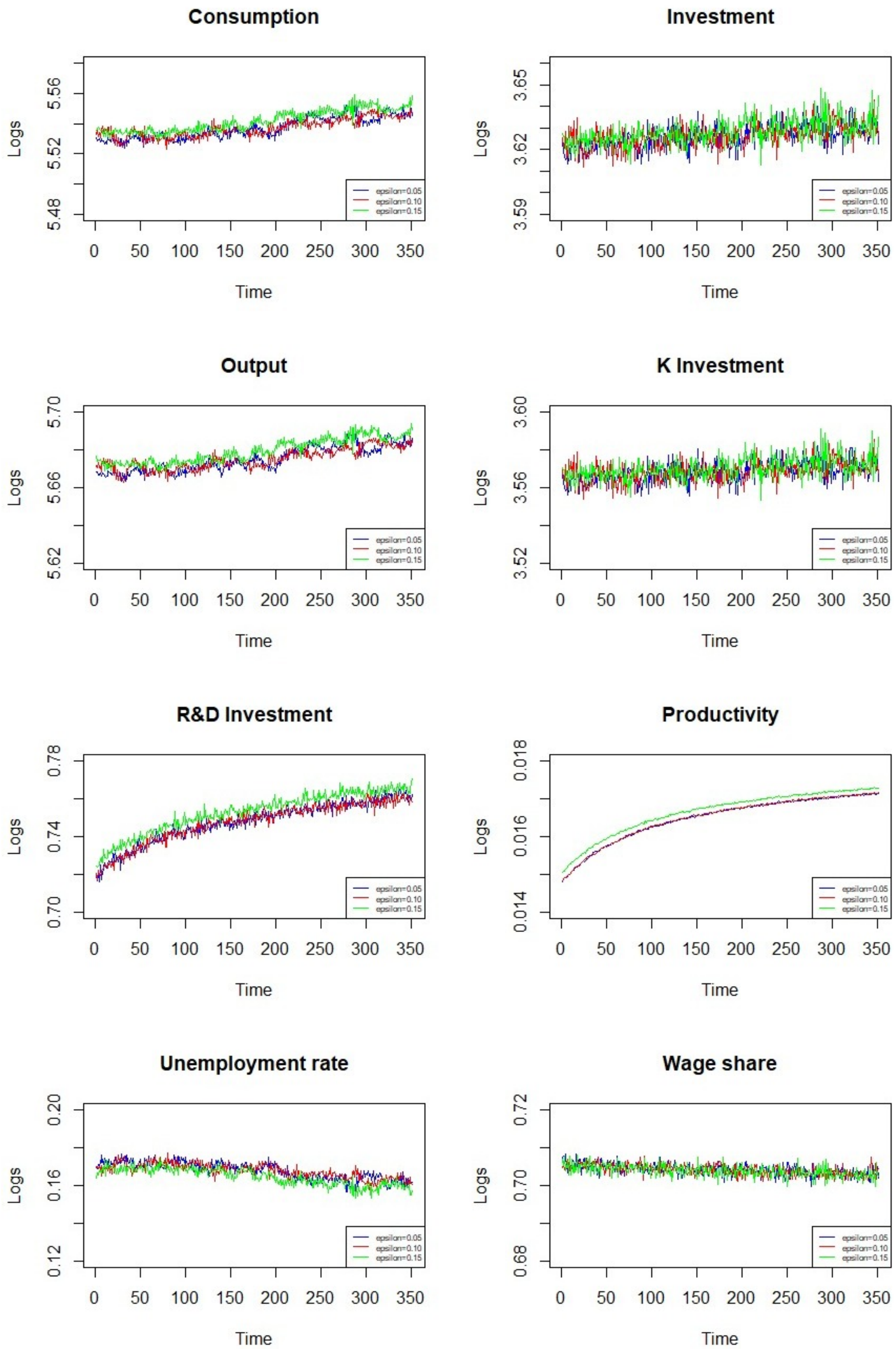


Figure 2.18. Policy experiment on ε

all these institutions in the last decades and that can help give a justification for the problem of Secular Stagnation as I defined it. Obviously, I admit that this is not the only valid reason for the long-run tendency of productivity growth to fall. Non-technological motives, like lower top marginal tax rates, increased low-skill immigration, rising trade with China and low-cost manufacturing countries or the rise of superstar firms (Autor et al., 2020) are equally plausible. As a side exercise, I tested also the role exerted by the rate of interest and the loosening of barriers to innovation and imitation. On the one hand, the decrease in the interest rate helps increase aggregate production and employment levels but impacts negatively on wage shares, since the entrepreneurs earn higher profits and prefer organizing the production process to less labour-saving techniques. On the other hand, loosening the barriers to the interaction among firms and increasing the possibility to exchange ideas through imitation allow for further innovation and better economic performances as a whole, but the effect is circumscribed to the long run only.

To conclude, though I am aware of the limitations of the model, the adoption of an agent-based framework helps reply to Prof. Robert Solow's call for more realistic micro-foundations (Solow, 2008). On the one hand, agent-based models allowed us to get and study the emergence of skewness and heterogeneity in firm's size distribution and productivity differentials; moreover, the firm-level analysis with its implications would not have been possible in standard economic models otherwise. As in (Bowles, 2009, p. 65): "An adeguate theory must illuminate the process by which group structure emerges in a population of individuals, how the boundaries among the resulting higher-level entities are maintained, and how they pass out of existence". Nonetheless, the model cannot deal with *growth* questions yet. I promise therefore I would improve the model to address these topics in Part II.

Appendix B

Data Appendix

This section provides with useful information the reader which wants to replicate Tabs. 2.1 to 2.6 and Figs. 2.1-2.2.

- **Adjusted Wage Share**: The Ameco database of the European Commission provides data of the adjusted wage share as percentage of GDP at factor cost since 1960. Data are accessible from url:"https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/macro-economic-database-ameco/ameco-database_en". Select Chapter 7 "Gross Domestic Product (Income Approach), Labour Costs", Sub-chapter 7.6 "Adjusted Wage Share".

- **Labour Productivity**: The variable has been measured as GDP per hours worked. Penn World Table 9.1 provides data since 1950. For any information, check url: "https://www.rug.nl/ggdc/productivity/pwt/pwt-releases/pwt9.1?lang=en". In particular, I multiplied the average annual hours worked with the number of person engaged in order to compute the amount of hours worked.

- **R&D expenditure by source**: *Source* refers to Federal, Industry, Nonprofits, Other and Total. Data are from the American Association for the Advancement of Science (AAAS), url: "https://www.aaas.org/programs/r-d-budget-and-policy/historical-trends-federal-rd". Select "National Totals", Series "National R&D by Funder, 1953 – 2017".

- **R&D expenditures by function**: *Function* refers to Federal expenditure in Defense and Nondefense, Energy, General Science, Health, Natural Resources, Space, Other. Data are from the American Association for the Advancement of Science (AAAS), url: ”https://www.aaas.org/programs/r-d-budget-and-policy/historical-trends-federal-rd”. Select “General Overview”, Series “By Function: Defense and Nondefense R&D Outlays, 1953 – 2020”.

- **R&D as Percent of GDP**: The reader can construct the series by simply taking data on Total R&D performed in the USA and Gross Domestic Product from BEA accounts or directly from the Federal Reserve Board of St.Louis, url: ” https://fred.stlouisfed.org/”.

- **Private R&D as Percent of Fixed Investments**: The reader can construct the series through BEA accounts or from the Federal Reserve Board of St.Louis, url: ” https://fred.stlouisfed.org/”. Related items refer to R&D as part of Gross Private Nonresidential Fixed Investments.

- **Federal R&D as Percent of Discretionary Outlays**: The US Senate defines *discretionary* spending the spending budget authority and outlays controlled in annual appropriation acts; check url: “https://www.senate.gov/reference/glossary.htm”. The American Association for the Advancement of Science (AAAS) provides data at url: ”https://www.aaas.org/programs/r-d-budget-and-policy/historical-trends-federal-rd”. Select “General Overview”, Series “R&D as a Percent of Discretionary Spending, 1962 – 2010”.

- **Federal R&D as Percent of Total Outlays**: The US Senate defines *Total outlays* as the amount of expenditure set out by the Federal Government; check url: “https://www.senate.gov/reference/glossary.htm”. The American Association for the Advancement of Science (AAAS) provides data at url: ”https://www.aaas.org/programs/r-d-budget-and-policy/historical-trends-federal-rd”. Select “General Overview”, Series “R&D as a Percent of Discretionary Spending, 1962 – 2010”.

- **Defense R&D as Percent of Defense Outlays**: The American Association for the Advancement of Science (AAAS) provides data at url: ”https://www.aaas.org/programs/r-d-budget-and-policy/historical-trends-federal-rd”. Select “General Overview”, Series “R&D as a Percent of Discretionary Spending, 1962 – 2010”.

- **Nondefense R&D as Percent of Total Budget**: *Total budget* identify the amount of expenditure set out by the Federal Government. The American Association for the Advancement of Science (AAAS) provides data at url: ”https://www.aaas.org/programs/r-d-budget-and-policy/historical-trends-federal-rd”. Select “General Overview”, Series “R&D as a Percent of Discretionary Spending, 1962 – 2010”.

- **Nondefense R&D as Percent of Nondefense Outlays**: *Total budget* identify the amount of expenditure set out by the Federal Government. The American Association for the Advancement of Science (AAAS) provides data at url: ”https://www.aaas.org/programs/r-d-budget-and-policy/historical-trends-federal-rd”. Select “General Overview”, Series “R&D as a Percent of Discretionary Spending, 1962 – 2010”.

Appendix C

More On The Model . . .

C.1 Notes on matching protocols: a simple economy framework

The note is about two matching processes that work in Agent-based Computational Economics (ACE) models. Features of the underlying economy are kept at minimum. Such protocols are suitable to more complex environments: actual applications are in Caiani et al. (2016b); Delli Gatti et al. (2005, 2010); Riccetti et al. (2015).

I focus on a one-good two-class closed economy with no government sector that is populated by a multitude of heterogeneous interacting agents. For the sake of simplicity, we have N households, in which $(N - F)$ are workers that offer labour inelastically at the going wage rate, while the remaining F households are capitalists such that each owns a single firm. Regardless of their status, everybody consumes and saves according to her propensity to save out of income. What is left from consumption in the form of savings, if any, is accumulated as cash holdings. For what concerns the production side of the economy, entrepreneurs organize the production process through the hiring of workers. I abstract from any investment decisions and assume that the single good is produced by means of labour only. Furthermore, I set any financial side of the economy away. Output is expressed at constant prices.

From what said, I express some equations that help me frame the protocols. The demand for labour of the i-th firm, n_d is equal to:

$$n_{d,i} = \frac{y_i}{a} \tag{C.1}$$

in which y is the amount of production and a is labour productivity, set for simplicity equal to 1. The wage rate w_r is set randomly by the each firm but cannot be lower than an exogenously-set subsistence amount. Labour costs are hence computed as:

$$wb_i = w_{r,i} \cdot n_{d,i} \tag{C.2}$$

in which wb stands for wage bill. Profits at firm level are defined as:

$$f_i = y_i - wb_i \tag{C.3}$$

For what concerns to price setting, firms fix prices as mark-up over unit labour costs:

$$p_i = (1 + \mu_i)\,\frac{w_{r,i}}{a} \tag{C.4}$$

in which the mark-up μ_i varies randomly between firms.

C.2 Matching 1: firms-workers network in the labour market

The setting above paves the floor to two matching protocols, in which the first applies to the labour market whereas the second relates consumers to entrepreneurs. Entrepreneurs hire workers to produce the consumption good. For simplicity, hiring workers consists of single-period agreements between agents and takes place randomly. Workers are randomly allocated to the i-th firm according to its labour demand $n_{d,i}$. The first step to build such a matching is to create a $F \times (N - F)$ matrix, called net_w. Cells take value 1 if a link between a firm and a worker is established and 0 otherwise. I then sample random cells and set them equal to 1: precisely, every row will count a number of 1s corresponding to the labour demanded by the i-th firm.[1] The second step concatenates the network matrix with a vector of ones as below:

$$net_{\boldsymbol{fw}} = [vcap, net_w] = \left[(1, \dots, 1)', net_w\right] \tag{C.5}$$

The vector of ones, $vcap$, refers to capitalists and assigns to each of them the same firm throughout the simulation. Moreover, it allows me to have a full network matrix in which the overall number of 1s actually corresponds to aggregate employment. Each simulation step will change values inside net_w – and so inside $net_{\boldsymbol{fw}}$ – but keeping fixed the first column of the latter matrix that refers to capitalists.[2] Last step of the first matching is about demand schedules for

[1] Careful readers will notice that the script below set the number of 1s as equal to $(n_{d,i} - 1)$: that holds since the entrepreneur works in her own firm too, so the *net* labour demand is $(n_{d,i} - 1)$.

[2] It follows that $net_{\boldsymbol{fw}}$ is a $F \times N$ matrix.

the consumption good. I have supposed in the above that the two classes consume with two different propensities out of disposable income, say α_1 for workers and α_2 for entrepreneurs.[3] In contrast, I set for convenience the propensity to consume out of wealth, α_3, as equal and constant among agents. I can therefore express the demand schedules as follows:

$$c_{w,j,t} = \alpha_{1,j} \cdot w_{r,j,t-1} \tag{C.6}$$

$$c_{e,j,t} = \alpha_{2,j} \cdot \left(w_{r,j,t-1} + f_{j,t-1}\right) \tag{C.7}$$

$$c_{mh,j,t} = \alpha_3 \cdot m_{h,j,t-1} \tag{C.8}$$

c_w, c_e and c_{mh} refer to the consumption out of worker's income, to the consumption out of entrepreneurial income and to the consumption out of wealth for the j-th agent, respectively. Firms pay to their workers a wage rate, $w_{r,i}$, that varies randomly across firms. I can make a $F \times F$ matrix, say $\boldsymbol{w_{r,\mathrm{diag}}}$, that contains wage values in its main diagonal. Such a matrix may then be multiplied by net_w, so to have a matrix for labour incomes in which every worker receives the wage from the firm she belongs to. I label this further $F \times (N-F)$ matrix with $\boldsymbol{w_{inc}}$:

$$w_{r,i} \longrightarrow \boldsymbol{w_{r}}_{,\mathrm{diag}} = \begin{bmatrix} w_{r,1} & \dots & 0 \\ \vdots & w_{r,i} & \vdots \\ 0 & \dots & w_{r,F} \end{bmatrix} \tag{C.9}$$

$$\boldsymbol{w_{inc}} = \boldsymbol{w_{r}}_{,\mathrm{diag}} \times net_w \tag{C.10}$$

$\boldsymbol{w_{inc}}$ might be, for instance:

$$\boldsymbol{w_{inc}} = \begin{bmatrix} w_{r,1} & \dots & 0 \\ \vdots & w_{r,i} & \vdots \\ 0 & \dots & w_{r,F} \end{bmatrix} \times \begin{bmatrix} 1 & 0 & \dots & 1 \\ \vdots & 1 & 0 & \vdots \\ 0 & 0 & \dots & 1 \end{bmatrix} = \begin{bmatrix} w_{r,1} & 0 & \dots & w_{r,1} \\ \vdots & w_{r,i} & 0 & \vdots \\ 0 & 0 & \dots & w_{r,F} \end{bmatrix} \tag{C.11}$$

Now, if every worker is assigned a marginal propensity to consume, $\alpha_{1,j}$, I am able to com-

[3] As in the standard Keynesian literature, $\alpha_1 > \alpha_2$ strictly holds.

pute the amount of consumption out of disposable income for all agents, c_w:[4]

$$c_w = \alpha_{\mathbf{1},\text{diag}} \times w_{\boldsymbol{inc}}^T = \begin{bmatrix} \alpha_{11} \cdot w_{r,1} & \dots & 0 \\ 0 & \alpha_{1i} \cdot w_{r,i} & 0 \\ \vdots & 0 & \vdots \\ \alpha_{1,N-F} \cdot w_{r,1} & \dots & \alpha_{1,N-F} \cdot w_{r,F} \end{bmatrix} \tag{C.12}$$

In particular, the transpose matrix $w_{\boldsymbol{inc}}^T$ makes clear that the propensity to consume does vary across workers but does not with respect to the single firm: that is, if the j-th worker is supposed to have a propensity to consume equal to 0.6, then this value is mantained regardless of the firm the agent decides to purchase the good.

The same procedure applies to capitalists, in that:

$$e_{\boldsymbol{inc}} = w_{\boldsymbol{r},\text{diag}} + f_{\text{diag}} \tag{C.13}$$

$$c_e = \alpha_{\mathbf{2},\text{diag}} \times e_{\boldsymbol{inc}} = \begin{bmatrix} \alpha_{21} \cdot (w_{r,1} + f_1) & \dots & 0 \\ 0 & \alpha_{2i} \cdot (w_{r,i} + f_i) & 0 \\ \vdots & 0 & \vdots \\ \alpha_{2F} \cdot (w_{r,1} + f_1) & \dots & \alpha_{2F} \cdot (w_{r,F} + f_F) \end{bmatrix} \tag{C.14}$$

in which f_{diag}, $\alpha_{\mathbf{2},\text{diag}}$, $e_{\boldsymbol{inc}}$ and $c_{\boldsymbol{e}}$ are all $F \times F$ matrices.

I combine $e_{\boldsymbol{inc}}$ and $w_{\boldsymbol{inc}}$ and get two full $F \times N$ matrices of disposable income and consumption, $y_{\boldsymbol{dh}}$ and $c_{\boldsymbol{inc}}$ respectively, that correspond to:

$$y_{\boldsymbol{dh}} = [e_{\boldsymbol{inc}}, w_{\boldsymbol{inc}}] \tag{C.15}$$

$$c_{\boldsymbol{inc}} = \left[c_e, c_w^T\right] \tag{C.16}$$

Since agents do not spend all their income in consumption, what is left is saved:

$$\partial m_h = y_{\boldsymbol{dh}} - c \tag{C.17}$$

[4] $\alpha_{\mathbf{1},\text{diag}}$ is a $(N-F) \times (N-F)$ matrix obtained through the same procedure adopted for $w_{\boldsymbol{r},\text{diag}}$.

∂m_h is a $F \times N$ matrix and tracks savings per period, while c represents the total household consumption, made up of two components: consumption of out income $c_{\boldsymbol{inc}}$ and consumption out of wealth $c_{\boldsymbol{mh}}$.[5] The latter is computed as follows:

$$c_{\boldsymbol{mh}} = \alpha_3 \cdot m_h \tag{C.18}$$

in which m_h is a $F \times N$ matrix representing the cumulative sum of savings ∂m_h.[6]

C.3 Matching 2: firms-consumers network in the goods market

The second matching process finds its application in Delli Gatti et al. (2005, 2010); Riccetti et al. (2015), among the others, but I refer to (Caiani et al., 2016b, pp. 64 – 67) for an exhaustive step-by-step explanation.[7] I here restrict the exposition to the rationale behind and I then conform the process to the current setting.

The main idea is that agents meet on the goods market and act following the same protocol: potential consumers observe a subset of prices from a restricted and random set of suppliers which reflects their imperfect information. They choose the best seller according to the lowest selling price. Households each period have the *chance* to switch to another supplier with a positive probability that depends on price differentials:

$$Prob = \begin{cases} 1 - e^{\chi_1 \cdot \frac{p_{new} - p_{old}}{p_{new}}} & \text{if} \quad p_{new} < p_{old} \\ 0 & \text{otherwise} \end{cases} \tag{C.19}$$

(C.19) says the larger the price differential between the old and the new price, the higher the probability to switch toward the new producer. The assumption considers the empirical fact that consumers establish a durable relationship based on trust and reciprocity to solve problems of asymmetric information (Bowles, 2009).

[5] Hence, $c = c_{\boldsymbol{inc}} + c_{\boldsymbol{mh}}$.

[6] The propensity to consume α_3 could have been set as α_1 or α_2. Previous reasoning would have applied in this case too. Moreover, $m_{\boldsymbol{h},t} = m_{\boldsymbol{h},t-1} + \partial m_{\boldsymbol{h},t}$.

[7] More precisely, Delli Gatti et al. (2005, 2010); Riccetti et al. (2015) and Caiani et al. (2016b) impose the same matching to related creditworthy enterprises to banks. In their case, firms choose their bank according to the interest rate charged on loans.

Chapter 3

Secular Stagnation and Innovation Dynamics: An Agent-based SFC Model. Part II

3.1 Introduction

The article extends the framework introduced with Part I and deals with the *growth* questions that surround the problem of Secular Stagnation in the United States. The debate on it has strengthened since 2014, when Larry Summers (2014a,b, 2015) recalled that old-fashioned concept to describe the post-2007 US economy. The focus was on structural changes in the economic fundamentals that have caused a significant shift in the natural balance between savings and investments, such that adequate growth, capacity utilization and financial stability would have become hard to achieve. Moreover, as Barry Eichengreen acknowledged, while the term "Secular Stagnation" spread quite fast in the literature, it is like Rorschach test: it means different things to different people (Baldwin and Teulings, 2014; Eichengreen, 2015). Accordingly, I move away from Summers's idea about Secular Stagnation and focus on a particular stylized fact: the long-run tendency of productivity growth to fall since the early Seventies.

The article contribution to the literature is either theoretical or empirical. It is *theoretical* because I develop an agent-based, stock-flow consistent model to analyze the nexus between functional distribution of income and innovative search in moulding productivity and economic growth. Such evolutionary and formal treatment of innovation and distribution is still largely unexplored in the literature on Secular Stagnation. Although the references to and analyses on Secular Stagnation recently intensified, a quantitative and empirical assessment is in fact still scant. A major attempt to provide the topic with a mathematical framework is Eggertsson et al. (2019): Secular Stagnation is there defined as a "persistently low or negative natural rate of interest leading to a chronically binding zero lower bound". The aim of that model is to contextualize Summers (2014a) in the New Keynesian framework. However, their model suffers from some limitations: the treatment of that particular kind of Secular Stagnation leaves the concerns for productivity and innovation dynamics as side results at best; additionally, the absence of substantial heterogeneity among agents and the commitment to a general equilibrium analysis are certainly a weakness.[1]

The implementation of an agent-based setting is, in contrast, particularly suitable to the task since the user knows by construction the micro data generating process and can explore the features of macro-variables as properties emerging out of the evolutionary dynamics (Dosi et al., 2018). More precisely, the agent-based framework is favourable for its focus on *macro-to-micro* and *micro-to-macro* channels that stand behind the surge of Secular Stagnation in the USA. The former route sets crucial phenomena as the social conflict between workers and entrepreneurs occur at macro-economic level, influencing entrepreneurial decisions about innovative search, employment and firm's competitiveness at the micro-economic level. On the contrary, the latter channel results essential in defining the market structure, its evolution over time, and the rise of skewness and persistent heterogeneity in firm's size distribution and productivity differentials. They in particular directly determine aggregate employment and production, and affect the bargaining process that results in the distribution of the social product between wages and profits. More importantly, the second linkage shapes the aggregate dynamics of innovation and productivity which are focal to the specific kind of Secular Stagnation I deal with. The theoretical model helps me show that the increase of the profit share at the expense of the wage share impacts negatively on firm's propensity and ability to innovate. When wages soar, the entrepreneurs will be forced to introduce labour-saving techniques through R&D, so to increase productivity and reduce unit labour costs. As a side result, I observe that the interest rate has non-linear and small effects on either economic growth or innovative activity. The very non-linearity arises because of the contrasting movement the rate of interest spurs on consumption and innovative search.

Secondly, the contribution to the literature is *empirical* because it aims at testing the main

[1]Cf. Di Bucchianico (2020) and Pyka and Fagiolo (2005) for specific and general limitations, respectively, detectable in models like Eggertsson et al. (2019)'s.

theoretical results on a panel of US manufacturing industries from 1958 to 2011. To be precise, I undertake a twofold empirical analysis based on panel cointegration techniques. Firstly, I find empirical evidence of a positive and long-period causal linkage from shipments and wages to R&D spending. The former identify the revenue and the cost components in the precedent theoretical model. I figure out that my series of interest are indeed cointegrated, i.e. there exists a long-run stochastic trend that joins them. I then detect positive and long-lasting evidences, confirming the predictions of my ACE model. The robustness of the results are assessed through the different econometric procedures usually applied to datasets with both large N and large T.
Secondly, I test the existence of a long-run relationship between R&D investments and the effective federal funds rate, on the one hand, and with the bank prime loan rate, on the other hand. I get the interesting result that no long-period well-established linkage exists between innovative effort and the interest rate, whatever measure I adopt for the latter. This lack means that any estimated regression of the former on the latter would provide me with spurious coefficients. Still, that does not conflict with my expectations. So doing, I find at least some plausible explanations for the rise of Secular Stagnation in the United States, among the other rationales often examined: non-technological motives, like lower top marginal tax rates, increased low-skill immigration, rising trade with China and low-cost manufacturing countries or the rise of superstar firms (Autor et al., 2020) are in fact equally admissible.

The paper is therefore organized as follows: Section II reviews the literature; Section III sketches the model; Section IV offers a broad view of the stylized facts the framework matches and related policy experiments; Section V tests some theoretical results empirically; Section VI concludes. The Appendix provides the reader with further information on the theoretical model.

3.2 Relation with the literature

The article draws upon several fields of research. Since it extends the reasoning started with Part I, this essay broadly shares the literature with it. I therefore refer the reader to the corresponding Section for further knowledge on the theoretical underpinnings of Secular Stagnation in the United States and about the general features characterizing many, if not all, agent-based evolutionary models.

In the present Section I focus on key contributions that strongly influence the theoretical background, on the one hand, and the econometric one, on the other. For what regards to the theoretical setting, this contribution extensively draws on the family of *Schumpeter meeting Keynes* ($K + S$, hereafter) models started with Dosi et al. (2006, 2010), and continued through Dosi et al. (2013, 2016, 2018) and Napoletano et al. (2012). This family investigates the way innovations affect macro-variables through the endogenous generation of supply shocks at the micro- and meso-level of economic activity. An important characteristic is that they link the Schumpeterian tradition of innovation-driven economic growth with the Keynesian theory of demand generation. Definitely, the Schumpeterian engine fuels growth only with Keynesian policies, which do contribute to reduce output volatility and unemployment rates. The general framework described in Dosi et al. (2006, 2010) is furthermore an exercise in *general disequilibrium* analysis, since it goes beyond the standard Walrasian framework that did not mean to address and detail how production, pricing and trade actually arise in real world economies.

The range of topics the $K + S$ framework may address is extended, and Dosi et al. (2013, 2016, 2018) and Napoletano et al. (2012) constitute just a sample of interesting contributions. Dosi et al. (2013) studies the interaction between monetary and fiscal policies, and functional distribution of income, through the development of a banking sector and a monetary authority that sets interest rates and credit lending conditions. The model has got a Minskyan flavour, in that a high volume of production and investments engenders the seed for future recessions. It indeed increases firms' debt with corresponding negative effects on net worth and rising credit risk. This process leads banks in turn to provide loans with tighter conditions or to apply credit rationing. Firms therefore curtail production, creating the premises for a crisis. Dosi et al. (2018) augments the $K + S$ framework to explain the emergence of hysteresis out of the interaction between heterogeneous firms and workers. Hysteresis comes out of coordination externalities and dynamic increasing returns that bear the functioning decentralized economies. This facet goes against the received view of hysteresis as outcome of market imperfections (Blanchard and Summers, 1986). Finally, Napoletano et al. (2012) studies how the interactions between firm's investment behaviour, wage formation and income distribution affect the short- and long-run aggregate dynamics of the economy. Investments can be driven by the stock of liquid assets or by expected demand. However and regardless of the scenario, a balanced distribution of income between wages and profits is focal to the emergence of stable growth paths with low unemployment rates.

A peculiarity of most $K + S$ models is the relevance assumed by fiscal policies: they not only dampen business cycles and reduce unemployment rates, but they are also effective in limiting the occurrence of major crises and fostering long-term growth. This implication is confirmed by Dosi et al. (2016) which aims at comparing short- and long-period effects of Keynesian policies *vis-à-vis* austerity rules for the European Union. They find that rules *à la* Stability and Growth Pact make the economy more volatile, with higher unemployment and prolonged crises. The corresponding depressing effects persist over the long term too.
Wirkierman et al. (2018) and Caiani et al. (2019) are on a similar line of research. The former focuses on the distributional impacts of innovation. The public sector invests directly in R&D and licenses to private firms access to the new technology to produce the final good. Increasing the wage share allows the public sector to drive the process of innovative search toward an outcome in which the distributional impacts of innovation reflect the distribution of contributions to the innovative process. In contrast, the latter investigates the nexus between inequality and growth, assessing the impact of several distributive regimes on innovation dynamics and economic development. The crucial feature is the segmentation of the labour markets in four tiers, according to the role assumed by each worker in the hierarchical organisation of the firm. The distributive regimes concern to the implementation of more, or less, progressive tax schemes and higher, or lower, downward wage rigidity of lower-tier workers. The results are in tune with the literature that emphasizes wage-led growth regimes in a closed economy: more progressive tax systems and measures to sustain low and middle income households help foster economic development and innovation.

For what concerns to the econometrics, I follow and contribute to the literature of time series techniques applied to panel data. These models aim at detecting long-run econometric relationships that typically involve meso- and macro-economic data. Long-period relations are often suggested by economic theory, and researchers are interested in such estimation techniques since they help provide supporting or contrasting evidence (Baltagi, 2008). The development of time series methods and its application to panel data covers a wide range of areas. Such methods include panel unit root tests, panel cointegration tests and the estimation of long-run coefficients. The range of application includes the literature on purchasing power parity (Pedroni, 2001, 2004; Pesaran et al., 1999; Pesaran and Smith, 1995), real wage stationarity (Fleissig and Strauss, 1997), international R&D spillovers (Gutierrez and Gutierrez, 2003; Kao et al., 1999), national innovation systems (Castellacci and Natera, 2013), environmental issues (Hamit-Haggar, 2012) and the relationship between R&D and capital investments (De Jong, 2007).

In particular, Pedroni (2004) tests the strong version of PPP for a panel of twenty countries for post-1973 years. Through a comparison between individual countries and the full panel, Pedroni strongly rejects the validity of strong purchasing power parity as a useful tool to describe post-Bretton Woods period. Fleissig and Strauss (1997) instead question the stationarity of real wage time series for G7 countries from 1960 to 1991, when possible. They find that real wage innovations are temporary, mean-reverting and stationary in all G7 countries but United States. Kao et al. (1999) re-examine Coe and Helpman (1995) analysis on the relevance of international R&D spillovers in supporting economic growth. The sample contains data on domestic and foreign R&D expenditure and TFP for 21 countries plus Israel during 1971 – 1990. They correct the estimation bias which affects Coe and Helpman (1995) results with two different estimators for long-period relationships. Although their results confirm the strong importance of domestic R&D in sustaining TFP growth, they also find the impact of foreign R&D as statistically insignificant.

On national innovation systems, Castellacci and Natera (2013) employs a panel of 87 countries over 1980 – 2007 to investigate the interplay between inputs and outputs of innovative search, on the one hand, and institutional factors such infrastructures and international trade, on the other hand, in shaping the dynamics of national systems of innovation. Despite the favourable evidence for the co-evolution of these factors in the panel as a whole, the specific trajectory followed by distinct national systems changes according to different levels of development. Hamit-Haggar (2012) focuses on Canadian industries over the period 1990 – 2007. The paper aims at studying the long-term causal relationship between greenhouse gas emissions, energy consumption and economic growth. Results provide strong support to the long-run impact of energy consumption on greenhouse gas emissions, while the relation between the latter and economic growth is non-linear. Moreover, estimation outcomes suggest that these variables influence each other in the long-term too, entailing the weakness of any one-way causality assumption. Finally, De Jong (2007) estimates the long-run linkage between capital investments and R&D in a panel of 36 pharmaceutical firms from 1992 to 2004. Estimation results suggest long-run causality exists and runs in both directions. More precisely, physical investments depends on the success of R&D over time since the latter requires additional facilities and equipment; at the same time, R&D is stimulated by capital investments in order to extend the success of current products.

3.3 A growth model for Secular Stagnation

The agent-based model I develop in this Chapter follows in the footsteps of Chapter II. There are few major differences I extensively discuss, but the overall apparatus is the same as before. For this reason, this Section provides a general overview of the model and focuses on which equations actually changed from the previous Chapter. All the other formal relationships are in the Appendix along with a short description of their meaning.

The model aims at analyzing the relations existing between functional income distribution, innovative search and productivity growth. Moreover, the model is still *complex*, *adaptive* and *structural* as in(Tesfatsion, 2006): complex for it involves interacting units; adaptive because it experiences environmental changes and structural because it builds on the representation of what agents do. Agents, N_s, differ according to their role in the labour market and in their consumption behaviour.[2] For what concerns to the labour market, an agent can be a worker or an entrepreneur. If (s)he is a worker, (s)he offers labour inelastically at the going wage rate and accepts whatever position an entrepreneur opens. For the sake of simplicity, I randomly assign a number of workers to a given firm according to its labour demand. Moreover, hiring workers consists of single-period agreements between agents; this condition means that each agent can move to another firm across periods. I think it is important to underline since the beginning that labour supply is exogenous and unbinding, such that real wages do not clear the market in a Walrasian fashion to ensure full employment; in contrast, the setting admits involuntary unemployment as the rule rather than a particular exception.[3] If the agent is, in contrast, a capitalist, (s)he owns one and (the same) only one firm throughout the simulation. Entrepreneurs take production and investment decisions, they carry out innovative search and may apply for loans if they have not enough retained funds to set up production. In particular, capitalists exert innovative effort to earn a greater amount of profits with a higher market share and to reduce unit labour costs, all through an improved technological apparatus.

The consumption behaviour entails a narrower dissimilarity between social classes than what is in the labour market. Agents, indeed, consume and save regardless of their status and the difference lies in the propensity to consume out of income, which is higher for workers than for businessmen.

[2] *Agent* is an encapsulated set of data and behaviours representing an entity residing in a computationally constructed world (LeBaron and Tesfatsion, 2008).

[3] There is no population growth. Moreover, in a mature capitalist economy as the USA are there is usually a pocket of unemployment, while episodes of labour shortages, if any, are solved through exogenous migration flows.

I again introduce a third type of agent, the bank, which is still consolidated and aggregate. Its activity is the same as before, in that it provides firms with loans and gather household's savings in the form of deposits. Additionally, each agent possesses a *share* of the bank, whose size is proportional to the amount of wealth (s)he has into. This condition gives the agent the right of receiving part of distributed banking profits as dividends. I stress right now that the presence of a passive bank is a limitation but not a major concern. On the one hand, I am not able to study the complex phenomenon of household and corporate debt that greatly substantiates the growth regime the USA has witnessed since the Eighties with a passive agent that does not discriminate between firm's creditworthiness and does not provide households with loans for mortgages. On the other hand, it is true that Secular Stagnation is multi-faceted and many intertwining causes are in place. My scope here is to analyze the specific role played by a macro-economic object, i.e. the social conflict between workers and entrepreneurs, in shaping a micro-economic feature, i.e. the development and adoption of novelties, which in turn addresses and explains the specific macro-economic phenomenon with which I have defined Secular Stagnation in the United States, that is the slowdown of productivity growth. In this way, an active banking system would only add further complexity.

The main novelty with respect to Chapter II consists of the introduction of some mechanisms that allows economic and productivity growth to arise. I figure out two main channels at work and I think a comparison with the previous Chapter is helpful. The first channel takes place at the macro-economic level and concerns to the social conflict between workers and entrepreneurs, and the respective bargaining process. In Chapter II, agents bargained over wage levels as in (3.1):

$$w_r = \left(w_0 - w_1 \cdot U_{r,t-1}\right) \cdot PR_t \tag{3.1}$$

in which w_r was the wage rate, $U_{r,t-1}$ the aggregate unemployment rate, and PR_t corrected for inflationary expectations, i.e. the higher the inflationary expectations the higher the wage rate; w_0 and w_1 were parameters: the former represented all the institutional factors as social norms, customs, market structures and political effects tying the wage rate to a certain path, while the latter did mimic the endogenous evolution of workers bargaining power in relation to unemployment dynamics. I amend (3.1) assuming the bargaining process occurs over wage growth as in (3.2):

$$g_{w_r} = w_1 - w_2 \cdot U_{r,t-1} \tag{3.2}$$

in which w_1 plays the same role as w_0 in (3.1), i.e. institutional factors that influence the wage path, while w_2 allows for a simple endogenization of the wage rate in that considers the negative influence from the unemployment rate in the labour market. The wage rate grows every period according to the balance of the social conflict as in (3.3):

$$w_r = w_0 e^{g_{w_r} t} \cdot PR_t \tag{3.3}$$

in which w_0 represents the initial value at the beginning of the analysis.

The second channel takes place within firm's decisions about innovative search and pricing rules. For what regards to innovation, in Chapter II firms invested to earn further profits and to save labour. This rationale was formally written as in (3.4):

$$i_{rd,j} = \vartheta_0 \cdot c_{av,j} + \vartheta_1 \cdot \left(\varrho_j - \bar{\varrho}\right) \tag{3.4}$$

in which $i_{rd,j}$ was the R&D amount of funds, c_{av} the average revenue from past sales of consumption goods, while $\left(\varrho_j - \bar{\varrho}\right)$ identified the discrepancy between the actual profit rate ϱ and the normal rate $\bar{\varrho}$; ϑ_0 and ϑ_1 were parameters whereas j indexed a firm. The first element on the right-hand-side was the *revenue* component, whereas the second element envisaged the *cost* component. In the present setting, I model the accumulation rate of R&D, $g_{ird,j}$ as in (3.5):

$$g_{ird,j} = \vartheta_0 \cdot \bar{g}_{y,j} + \vartheta_1 \cdot \left(\frac{\bar{\varrho}_j - \varrho_j}{\bar{\varrho}_j}\right) \tag{3.5}$$

Such accumulation rate depends upon a revenue and a cost component as before: the former is $\vartheta_0 \cdot \bar{g}_{y,j}$, in which ϑ_0 is always a parameter while $\bar{g}_{y,j}$ involves a more complex learning process for entrepreneurs than in (3.4). They indeed no longer consider only the average amount of consumption good sold in the past; they now take into account the amount of investment goods they produced for other firms too. More precisely, they form their expectations over average production growth they did experience in the past. However, they do not consider in their expectations the past as a whole, but they give more importance to recent developments: $\bar{g}_{y,j}$ is therefore computed as a moving average of last periods, to reflect either a gradual learning behaviour or the greater meaning each firm gives to more recent events than what experiences in the very past.

The second element, $\left(\frac{\bar{\varrho}_j - \varrho_j}{\bar{\varrho}_j}\right)$ significantly differs form the corresponding cost component of (3.4). I here desire to consider two forces at work. Firstly, the normal profit rate is computed as a moving average as $\bar{g}_{y,j}$, to remark the entrepreneurial learning process over the overall profitability innovative efforts entail. In this way, we have that continuously high profit rates affect positively innovative expenditures in the medium-to-long period.[4] However, the actual profit rate may negatively influence innovative effort and the argument runs as follows: high unemployment and increasing bargaining power of capitalists will reduce the speed with which wages increases, entailing therefore a rise in the rate of profit. Such a reduction will decrease the incentive to adopt labour-saving techniques because the discrepancy and the desire to reach a normal profit rate shrink; the fear for competition seems also attenuated. Capitalists find then a diminished incentive to further mechanize production.[5]

On the pricing rule, firms set prices as mark-up over unit labour costs as I have already written in Chapter II. However, the market share affect the evolution of the mark-up and not simply its level:

$$g_{\mu,j} = v \cdot (\sigma_{m,j} - \bar{\sigma}) \tag{3.6}$$

In this way, capitalists will increase the mark-up through a factor $g_{\mu,j}$ which is set according to the discrepancy between the actual market share and the median share in market $\bar{\sigma}$; v is still a coefficient. The rationale is the higher the market share, the higher the willingness and the incentive to raise the mark-up factor, and vice-versa.

The complexity of the model, i.e. the presence of interacting units, envisages what the literature calls *procurement process* (Tesfatsion, 2006). For instance, if we considered the consumption good market, customers would have to decide how much to purchase and at what prices. They must choose a partner among a narrow set of potentials. Once a seller is selected, the customer-supplier relationship involves a long-term commitment. The assumption considers the empirical fact that consumers establish a durable, but not everlasting, relationship of trust and reciprocity to solve problem of asymmetric information.[6] In addition to this, agents interact with each other on five different markets: the (capital) goods market in which firms buy and sell (investment) goods; the (consumption) goods

[4] This idea is common to the Post-Keynesian literature as in Hein (2012); Lavoie (2014).

[5] Dutt (2006); Hicks (1963); Marx (1867) and Hein (2012) provide further details.

[6] "Individuals take decisions according to the limited set of information they have, rational decisions are substituted with reasonable decisions, optimal choices with *satisfying* choices, rational expectactions with experience-based *rules of thumb*" (Bassi and Lang, 2016, p. 37). This is tantamount to say that agents have a Simon-type rationality schedule. I concretely apply this assumption with the matching protocol used by Delli Gatti et al. (2005) and Riccetti et al. (2015); more on that in the Appendix.

market, in which firms trade goods with households; the labour market, in which capitalists hire and fire workers; the credit market, in which the bank provides firms with loans and the deposit market, in which the same bank gathers households savings in the form of deposits.

To conclude this Section, I briefly sum up the timeline of events, though there is no difference from the model in Chapter II. At the dawn of time, I endow firms each with a unit of goods, as their starting level of capital stock. Entrepreneurs compute the target level of capital and, in order to set up production, they may either borrow from the banking system at given interest rates or draw from previous accumulated profits. Once revenues from sales accrue to the firm, they are distributed as wages and profits. Agents spend part of the received income for consumption purposes and save what remains. The bank collects interest payments from firms and rewards households deposits; additionally, it distributes banking profits to households in proportion to respective wealth. Finally, firms update production plans and perform innovative search: any achievement in productivity will be available at $t + 1$, once the cycle re-started again.

3.4 Validation and policy experiments

3.4.1 Empirical validation: stylized facts

The model is run through 400 periods that roughly correspond to quarters. The baseline scenario is performed along 100 Monte Carlo simulations to wash the variability across runs away. The use of Monte Carlo averages might none the less be problematic according to the model: in a case of quasi-deterministic models it is likely that the evolution of the economy is similar in multiple simulations, whereas more erratic models can exhibit cycles in different periods of the simulation. In the second case, averaging Monte Carlo runs and assessing the results of the simulations based on the mean and confidence intervals can be misleading. The risk is to averaging out interesting phenomena which are only detectable when the dynamics of each simulation is analyzed. A scrupulous study of single simulations reveals however that such case is not a major problem in the present setting, as it was not in Part I. As common to the majority of ACE models, it does not allow for analytical, closed-form solution. The reason stands in the many non-linearities that distinguish agent decision rules and their pattern of interactions. Agents, firms *in primis*, start from a symmetric condition. For example, firms are endowed with an equal amount of capital goods at the beginning of the simulation. However,

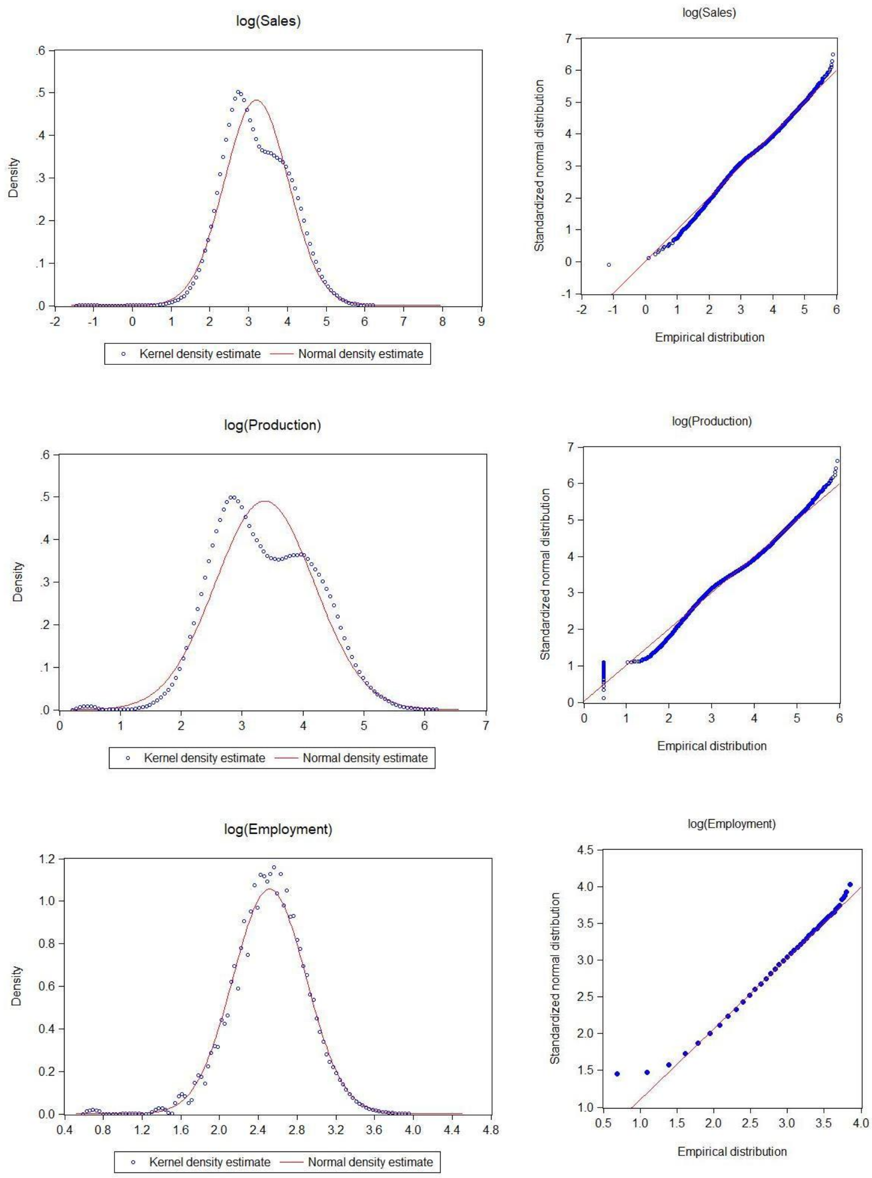
Stylized facts	Tables - Figures	References
Micro-economic level (firms)		
Skewness and heavy tailed-ness in firm size distribution	Fig. 3.1	Bottazzi and Secchi (2003, 2006)
Moments of size distribution are stationary (but not the mean)	Tab. 3.2, Fig. 3.2	Bottazzi and Secchi (2003); Dosi et al. (2010)
Heterogeneous productivity and Laplace-distributed growth rates	Fig. 3.3	Bartelsman and Doms (2000); Bottazzi and Secchi (2003)
Investment heterogeneity and lumpiness	Figs. 3.4- 3.5	Caballero (1999); Doms and Dunne (1998)
Persistence of R&D	Tab. 3.3	Caballero and Hammour (1991); Harhoff (2000); Le Bas and Scellato (2014)
Macro-economic level (aggregate)		
Endogenous and self-sustained growth	Fig. 3.6	Caiani et al. (2019); Dosi et al. (2010)
Fluctuations at business-cycle level	Fig. 3.6	Caiani et al. (2016a); Dosi et al. (2010); Stock and Watson (1999)
Stock-flow consistency	Fig. 3.7	Godley and Lavoie (2006)
Output, investment, consumption and unemployment are non-stationary	Tab. 3.4	Blanchard and Summers (1986); Hamilton (2020); Nelson and Plosser (1982)
Cross-correlation among macro-variables	Tab. 3.5	Stock and Watson (1999)
Pro-cyclical R&D	Tab. 3.5	Wälde and Woitek (2004)
Volatility of output, investment, consumption and unemployment	Fig. 3.9	Caiani et al. (2016a); Dosi et al. (2010); Stock and Watson (1999)

Table 3.1. Stylized facts matched by the growth model

the starting symmetry does not prevent heterogeneity comes out in the subsequent stages of development at all, as outcome of agent interactions. For what concerns to parameters and exogenous coefficients, I either borrow from the literature or given reasonable values to match and not to clash with the former. Precisely, key coefficients in key behavioural equations are given stochastic values that vary across agents as in Tab. D.1.

How does the model fare with the empirical facts? I carry out an empirical validation to check whether the model is able to replicate at least some of the wide spectrum of micro-economic and macro-economic stylized facts. Tab. 3.1 reports to the wide spectrum of stylized facts matched by the model.

For what concerns to micro-economic stylized facts, the model matches five well-established empirical evidences. First of all, firms size distribution is skewed and heavy tailed as in Bottazzi and Secchi (2003, 2006). I focus on three proxies for firm size, i.e. sales of consumption goods, overall production and number of employees. Fig. 3.1 shows two different sets of plots: on the left-hand-side, we see the Kernel density for log-transformed data surrounded by a normal distribution; on the right-hand-side, I computed the simple normal probability plot. Simulated data can be well approximated by a log-Gaussian distribution with a sign of bi-modality. It is interesting to make a quick comparison with the model in Part I. When the model gravitates around a stationary state, the gamma distribution fits perfectly firm's size distribution. The gamma function in this case is either less skewed or less heavy-tailed than the present log-normal distribution. Therefore, the presence of economic growth in the model favours the rise of higher asymmetry and inflates the kurtosis in firm's size distribution. This feature, again, can be obtained through an ACE models only, being standard methodologies not able to outline such an evidence.



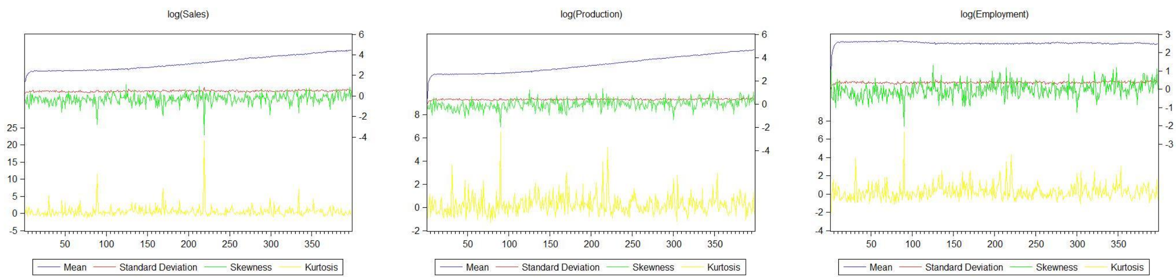
Note: sales refer to shipments of consumption good, while production is about shipments of consumption and investment goods.

Figure 3.1. Firm size distribution

	Consumption		Production		Employment	
	Trend β	ADF test	Trend β	ADF test	Trend β	ADF test
Mean	0.006	0.791	0.006	0.876	−0.0001	−4.109
	(0.000)	(0.994)	(0.000)	(0.995)	(0.014)	(−0.001)
Standard deviation	0.003	−4.812	0.0002	−5.527	0.0001	−8.429
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Skewness	0.001	−18.765	0.001	−10.828	0.001	−10.978
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Kurtosis	$8.10E-05$	−18.426	0.0003	−17.820	0.001	−17.815
	(0.900)	(0.000)	(0.390)	(0.000)	(0.106)	(0.000)

Note: p-values in brackets.

Table 3.2. Moments of (log)size distribution



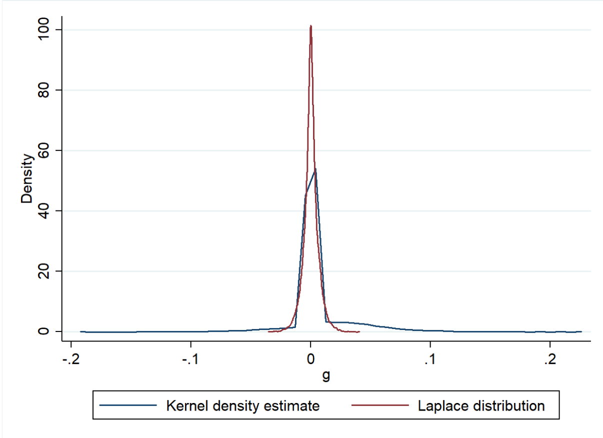
Note: sales refer to shipments of consumption good, while production is about shipments of consumption and investment goods.

Figure 3.2. Moments of firm size distribution

Secondly, Tab. 3.2 and Fig. 3.2 show that standard deviation, skewness and kurtosis of firms size distribution are stationary processes though they present a very tiny time trend. The first moment, in contrast, exhibits a unit-root process according to the standard ADF test. This result holds for the size proxies of sales and production but not for employment. The non-stationarity of the mean is in tune with Dosi et al. (2010) but not with Bottazzi and Secchi (2003), though in the latter the first moment presents a significant and positive trend.

Thirdly, firms are very heterogeneous in terms of productivity and, again, are described by a log-normal distribution.[7] Additionally and still in tune with observed real data, productivity growth rates at firm level are Laplace distributed, so again the distribution is fat-tailed as in Fig. 3.3. Productivity levels are quite dispersed and differences reflect the differences in the outcomes of technological bets: even if the entrepreneurs bet the same, they may not reap the

[7] I computed the Jarque-Bera test for my log-transformed variables for each time period: I could not reject the null hypothesis of normality for the strictly vast majority of the cases. Results are not displayed for brevity reasons; they are available upon request. Furthermore, heterogeneity in productivity is more pronounced than in Part I.



Note: estimates refer to productivity changes at firm level.

Figure 3.3. Productivity growth distribution

same rewards because of uncertainty (Bartelsman and Doms, 2000).[8]

Fourthly, investment is heterogeneous and *lumpy* as in Figs. 3.4 and 3.5: on aggregate, firms experiencing investment spikes co-exist with firms having *near* zero investment. A wide body of literature finds that investments in manufacturing plants is characterized by periods of intense activity interspersed with periods of much lower one (Doms and Dunne, 1998). Moreover, investment spikes correspond to single episodes and are unlikely to wash out on aggregate (Caballero, 1999). This feature rises the question on whether investment is lumpy. Lumpiness means that the same firm switches from periods of high- to period of very low investment expenditures. I plot in Fig. 3.5 the investment-to-capital ratio pattern of a selected j-th firm and I notice the presence of few high-investment periods alternating periods of much lower activity.[9] However, we should judge that evidence with care: investment lumpiness in modeling comes out of (S, s) investment functions as in Caballero (1999). Although I did not posit any discontinuous investment schedule, such discontinuities arise out of two main determinants: on the one hand, the matching process between firms and consumers continuously modifies the demand each single firm faces; on the other hand, productivity within the firm may jump to higher values as the result of innovation and imitation, with the important consequences in terms of labour demand. All lead to high-investment periods

[8]The literature treated firms size distribution and productivity growth rates as if they were independent and separated phenomena. Delli Gatti et al. (2005) explore the link between the two and argue that firms size distribution lays at the root of the Laplace distribution of growth rates. Additionally, many features of business cycle fluctuations, e.g. age of existing firms, amount of profits and "bad debt", follow as a consequence of firms size skewness.

[9]The upper bound is computed as the median value across time plus the standard deviation. Similar pictures are discernible for each other firm, whose related graphics are available upon request.

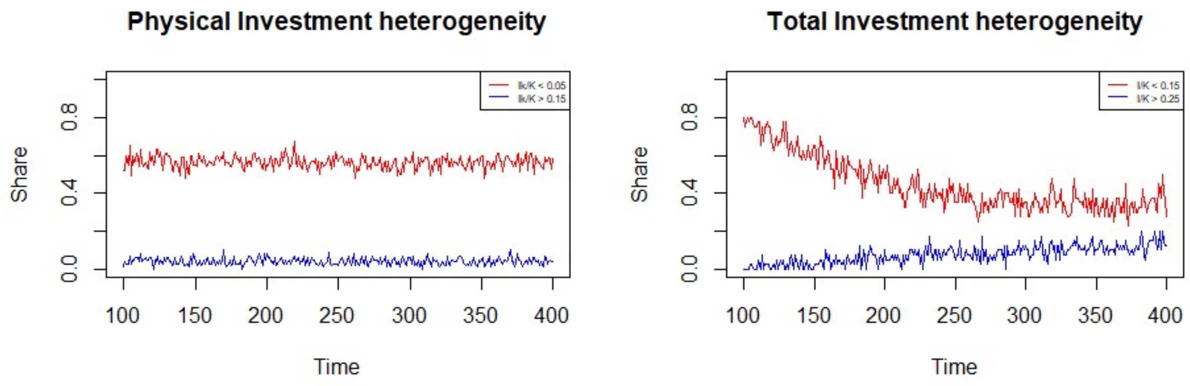
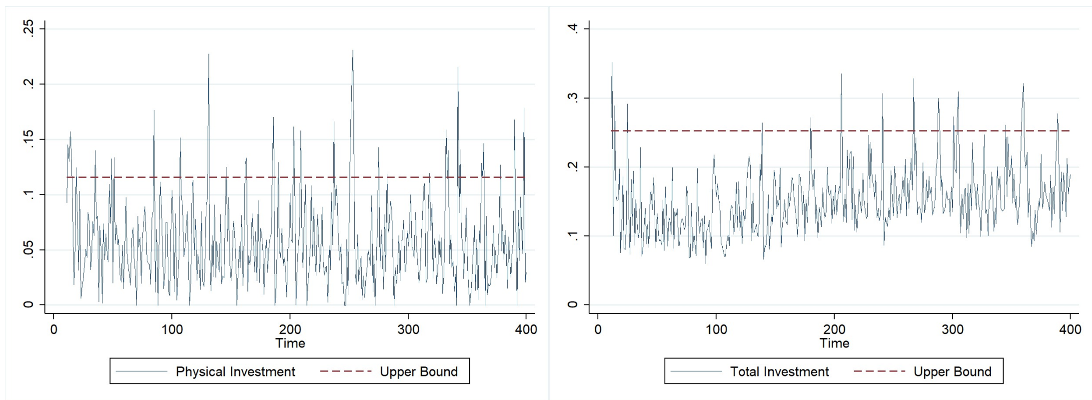


Figure 3.4. Investment heterogeneity



Note: investment patterns from a selected firm; the upper bound is determined as median value plus one standard deviation.

Figure 3.5. Investment lumpiness

followed by longer periods of stillness.

Lastly, I want to stress the *persistence* of R&D investments at firm level as in Tab. 3.3. Firstly highlighted by Caballero and Hammour (1991), the persistence in R&D expenditures reflects the fact that researchers cannot be hired and subsequently fired without a substantial loss of firm-specific know-how that cannot be easily re-allocated to other activities (Falk, 2006). The creation of a R&D lab implies a long-run commitment characterized by sunk costs and firms will have a strong tendency to smooth innovative spending over the business cycle more than what they usually do with ordinary physical investments (Mulkay et al., 2001).[10] For simplicity, I detect persistence by testing for unit roots in the panel of simulated firms: I find

[10]The literature emphasizes two other major causes for the persistence in R&D spending: the "knowledge accumulation" hypothesis, that relates the experience in innovation with learning-by-doing mechanisms, and the "success-breeds-success" hypothesis, that sheds light on the simultaneous influence between innovation and long-lasting profitability. On the several reasons behind R&D persistence, I suggest Harhoff (2000); Manez et al. (2009); Suárez (2014). Le Bas and Scellato (2014) is a synthetic review.

Panel unit root test	LLC	IPS	ADF-Fisher χ^2	PP-Fisher χ^2
R&D	32.422	13.322	1.229	72.702
	(1.000)	(1.000)	(1.000)	(0.706)

Note: numbers in brackets denote p-values; I adopt the Schwarz-Bayesian criterion to select the optimal lag length. The null hypothesis assumes a common unit root process in the LLC test, while individual unit root process in the others.

Table 3.3. R&D persistence at firm level

that all innovative investments are $I(1)$ processes, i.e. they exhibit a high degree of persistence and serial correlation across time. The source of persistence comes out of the watchful process of reflection through which firms do continuously, though slowly, adapt their expectations over future demand.

The model does also replicate a good ensemble of macro-economic stylized facts. First, Fig. 3.6 shows the general pattern of key variables of interest: output, consumption, investments and related components, labour productivity, deposits, unemployment rate and the wage share. The model generates endogenous and self-sustaining growth path characterized by clear, though tiny, fluctuations at the business-cycle frequency. The unemployment rate converges and gravitates around the reasonable value between 10 and 15 percent, while the wage share converges to 70% in the very long run. The model is stock-flow consistent as in Fig. 3.7: the adoption of stock-flow norms since the very beginning dampens the arbitrariness of behavioural parameters and the influences from purely stochastic factors.

Second, a recent debate in the literature emphasizes the problem of Harrodian instability in agent-based models (Botte, 2019; Franke, 2019; Russo, 2020). More precisely, although firms strive to reach a normal capacity utilization rate at the micro-economic level, the accelerator effect from their investment schedule does not allow firms to satisfy their objective on aggregate (Botte, 2019).[11] However, the heterogeneity among firms can help solve the puzzle: Russo (2020) introduces firm-specific shocks in their demand expectations that lead to endogenous business-cycle fluctuations in which capacity utilization does not exhibit explosive dynamics

[11] Botte (2019) finds that full-employment ceiling stops the upward Harrodian instability, while an autonomous source of expenditure helps tame the downward instability. Franke (2019) shows the emersion of Harrodian instability from a neo-Kaleckian agent-based model in which firms continuously switch between optimistic and pessimistic expectations. Nevertheless, once he adds a third state with *neutral* expectations, the Harrodian instability is tamed if the economy settles into an equilibrium with an equal share of optimists and pessimists that co-exist with a higher share of neutrals.

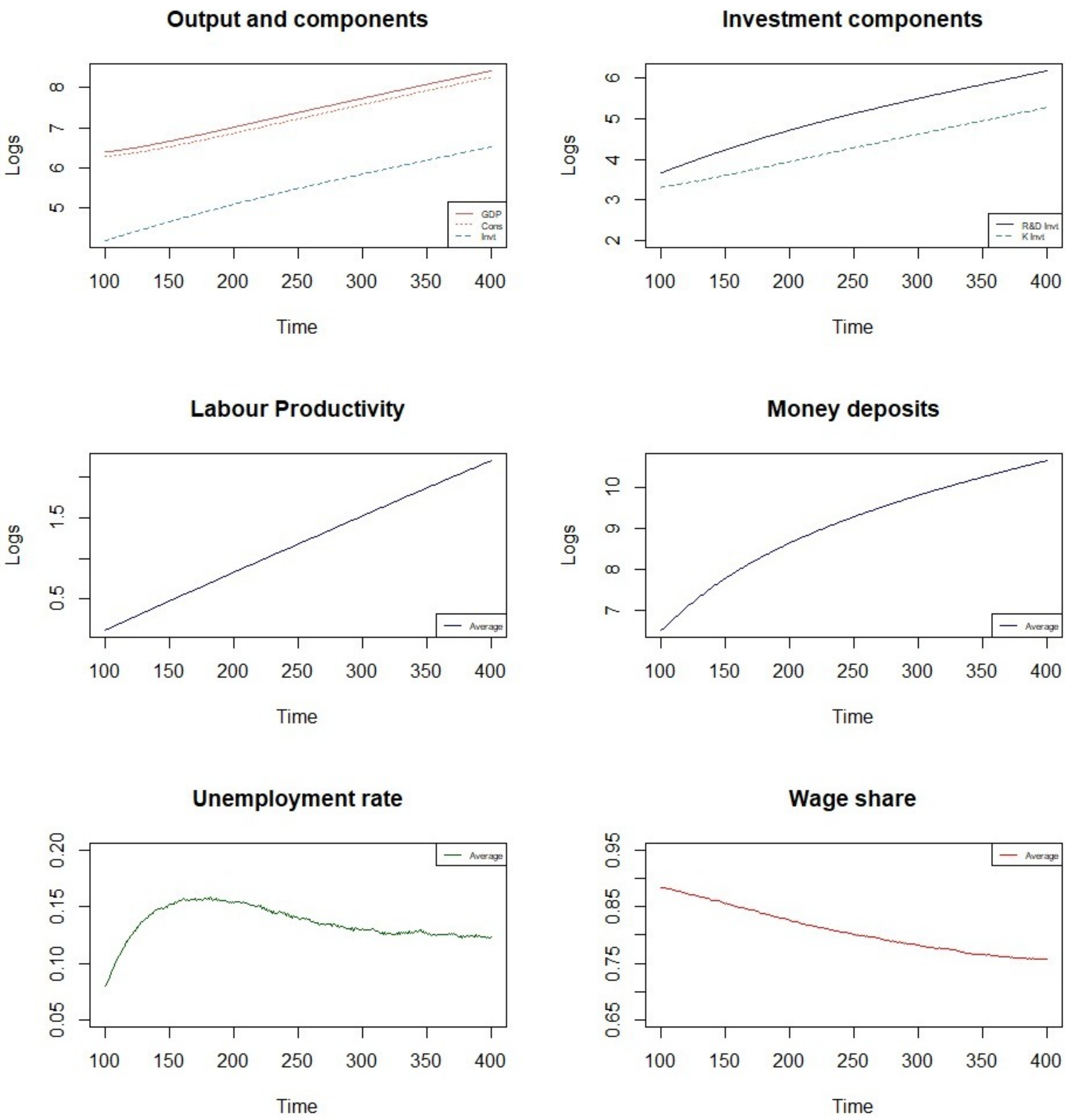


Figure 3.6. Baseline model: levels in log terms

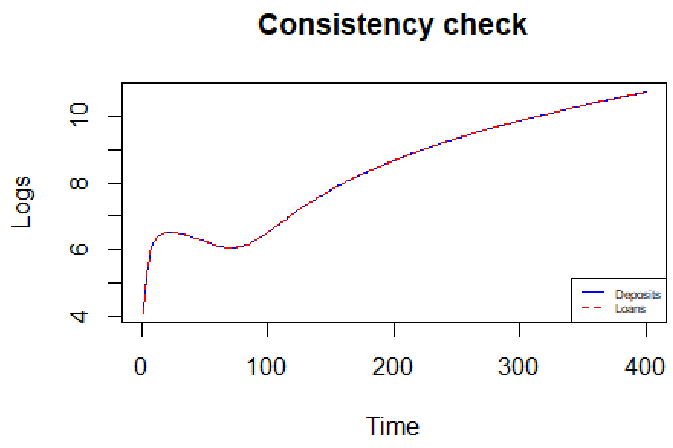


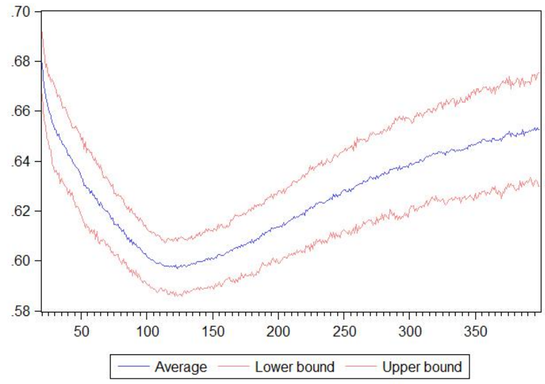
Figure 3.7. Stock-flow consistency check on selected simulation

anymore. My setting has several sources that may tame such an instability. First, firms are highly heterogeneous in their investment behaviour and expectations about future demand. In this picture, the matching process between firms and consumers helps lead to a configuration in which optimistic expectations may be counterbalanced by pessimistic ones on aggregate. Secondly, innovative investments are productivity-enhancing: this process has a negative effect on employment rates such that aggregate consumption could fairly decrease, *ceteris paribus*. Fig. 3.8 shows the long and gradual convergence of capacity utilization toward an average 70 percent. In addition to this, it is worth remarking that business cycles are not a product of stochastic factors but they are endogenous to the model: the matching with consumers and the rise of heterogeneity subject a firm to experience periods of booms and recessions, and to revise its expectations accordingly.

Third, Tab. 3.4 computes some brief statistics on output, its components and the unemployment rate. The simulated time series present strictly positive average rates of growth and exhibit a unit root. The latter is ascertained through two different unit-root tests so to get robust results. Either the ADF or the KPSS test confirm that all the variables exhibit a unit root, well in tune with the empirical evidence.[12]

Fourth, Fig. 3.9 compares the volatility structures of most important variables: consumption, investment, output and the unemployment rate. Still in tune with observed data,

[12]The unemployment rate follows a fat-tailed distribution whose related figure is not reported for the sake of brevity; it is however available upon request.



Note: bounds are the confidence interval at 95% level; average and bounds are computed across Monte Carlo runs.

Figure 3.8. Aggregate capacity utilisation rate

	Output	Investment	Consumption	Unemployment
Average	0.011	0.006	0.008	0.125
ADF test	−0.832	−0.094	−1.649	−1.365
	(0.809)	(0.948)	(0.457)	(0.60)
KPSS test	2.472	2.474	2.472	0.359
	(0.739)	(0.739)	(0.739)	(0.347)

Note: averages refer to growth rates for output and its components. P-values and critical value at 1% in brackets for the ADF and the KPSS tests, respectively. For what concerns to the unemployment rate, KPSS critical value corresponds to 10% significance level.

Table 3.4. Output, investment, consumption and unemployment statistics

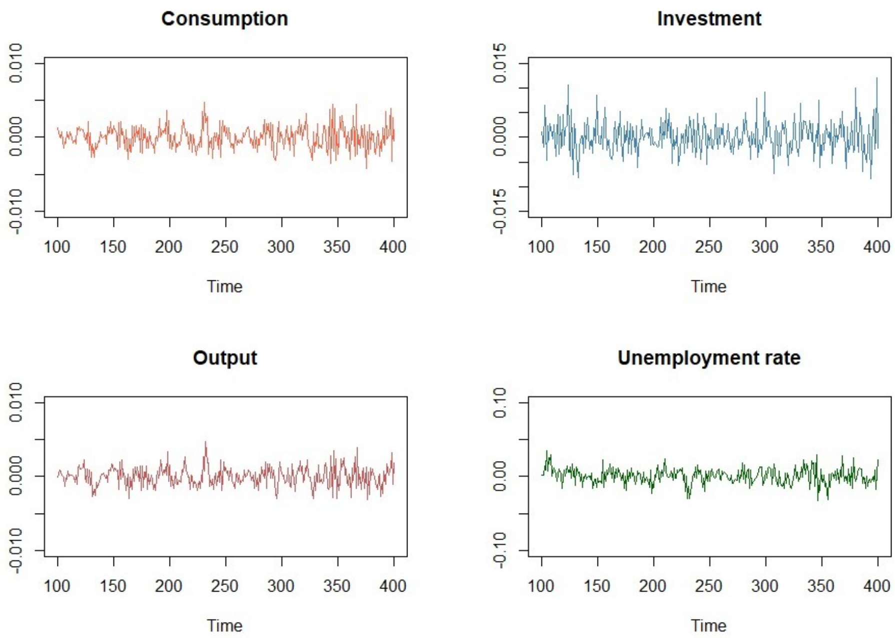


Figure 3.9. Cyclical components of simulated time series for some aggregate variables

unemployment and investments turn out to be more volatile than output and consumption, the latter exhibiting almost the same volatility.[13]

Finally, the model matches the business-cycle properties about correlation structures, as Tab. 3.5 displays. The table contains cross-correlation coefficients for each aggregate with respect to output. I computed such values considering a wide spectrum of time periods, from $(t-5)$ to $(t+5)$, and associated estimates with a star when significant at 5% level. Investments and labour productivity appear pro-cyclical and leading while consumption tends to synchronize with the business cycle; the unemployment rate is counter-cyclical and lagging. We get from the same table that R&D is pro-cyclical. There is an interesting debate in the literature on the cyclicality of innovative expenditures: the basic argument says that whenever firms experience a sales boom and in the absence of tight credit constraints, they prefer allocating their human and physical assets to current production; hence, longer-term innovative investments should be counter-cyclical, while short-term investments are pro-cyclical (Aghion et al., 2010, 2012; Chiao, 2001; Rafferty and Funk*, 2004). Empirical evidence on that is contrasting and my results are more in line with Dosi et al. (2018), Napoletano et al. (2006) and Wälde and Woitek (2004).

[13] I have separated trends and cyclical components using the Hodrick-Prescott filter; cf. Napoletano et al. (2006) and Fagiolo et al. (2008).

Series (HP cycle)	Output (HP cycle)										
	$t-5$	$t-4$	$t-3$	$t-2$	$t-1$	t	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$
Consumption	−0.035	0.045	0.268*	0.401*	0.814*	0.88*	0.578*	0.36*	0.172*	0.036	−0.066
Investment	0.103	0.155*	0.326*	0.391*	0.696*	0.601*	0.13*	−0.051	−0.208*	−0.264*	−0.28*
Output	−0.07	0.045	0.214*	0.429*	0.724*	1*	0.724*	0.429*	0.214*	0.045	−0.07
K Investment	0.108	0.166*	0.323*	0.405*	0.685*	0.632*	0.287*	0.007	−0.232*	−0.323*	−0.354*
R&D Investment	0.077	0.11	0.273*	0.3*	0.593*	0.447*	−0.15*	−0.139*	−0.131*	−0.121	−0.11
Productivity	0.078	0.11	0.273*	0.299*	0.595*	0.445*	−0.154*	−0.141*	−0.132*	−0.122*	−0.109
Unemployment rate	0.137*	0.085	0.124*	−0.009	0.071	−0.286*	−0.737*	−0.485*	−0.314*	−0.165*	−0.067

Note: star for statistical significance at 5%.

Table 3.5. Correlation structure

To conclude, I want to point out that the observed features are not simply dependent on a specific parameterization of the model: had parameters been different, its inherent properties, in terms of correlation structures and so on, and the way variables impact on each other would have been the same and not tied to the specific set of parameters (Caiani et al., 2016a).

3.4.2 Policy experiments

I have ascertained the ability of the model to replicate some facts observed in real data. The aim of this Section is to ask the model how the economy behaves when I change the value of some parameter of particular interest. I investigate the properties of the model over a different set of scenarios and then I compare the results.
The model has been developed to study the problem of Secular Stagnation in the USA from a demand-side perspective, and precisely I want to study the role played by the functional distribution of income in spurring firm innovative search. Beside that, I want to assess whether the rate of interest does play any role in stimulating the introduction of new technologies.

For what concerns to the role played by income distribution, I must remind from Chapter II that disagreement on its effects still characterizes the literature. On the one hand, there is a widespread belief that distributions of income more favourable to labour, the improvement of social protection systems, the centralization of the collective bargaining structure helps production, capital accumulation and productivity experience higher growth. On the other hand, some might argue that a distribution of the social product more favourable to wage earners dampens firm dynamism. Profit-financed investments would be reduced because of the lower funds aimed at supporting them. Setting a distribution of income more favourable to profit earners helps therefore increase output and employment.
I can test which theory prevails through the parameter w_1. To remind, it identifies all the

institutional, social and political factors that help the growth of the wage rate. The higher the values, the greater the labour bargaining power and so the higher the wage growth. Fig. 3.10 shows the effect of different scenarios, each performed along 25 Monte Carlo runs. Wages sustain the demand for consumption commodities, on the one hand, and innovative investments on the other. The Schumpeterian entrepreneurs will invest in physical capital to enlarge the stock and not to lose clients. When wages soar, the profit rate drops with respect to the target; the entrepreneur will be forced to introduce labour-saving techniques through the R&D so to rise labour productivity and reduce unit labour costs. The need to counterbalance the increase in the labour cost with the introduction of enhancing-productivity techniques is essential to reduce the unit price or to keep it constant, at least. This need is crucial for her competitive position in the market. Firms find more convenient to adapt production to more labour-saving techniques. However, it is worth remarking that the positive effect prevails over a negative and counterbalancing effect caused by the decrease in the profit rate. Nevertheless the social compromise more favourable to workers leads to technological unemployment. We see from the corresponding panel in Fig. 3.10 as the higher w_1, the higher the unemployment in the economy. The rate with which entrepreneurs introduce technological innovations is greater than output growth: it means that productivity grows more than production and, by definition, employment lessens. This feature is in contrast with what happened in Chapter II, when social compromises more favourable to labour clearly let unemployment decrease. Finally, the wage share does not display any clear pattern, and converges to a value between 70% and 80% in the long period: capitalists restore a constant profit share through productivity-enhancing techniques even with social compromises less beneficial to them. Anyhow, the overall result is a better economic performance on aggregate, with higher output growth, higher productivity growth though with slightly higher unemployment.

For what regards to the rate of interest, the economic literature always asked whether, and how, the interest rate stimulates economic activity. The standard neoclassical belief is that a cut in the rate of interest triggers a twofold mechanism. Firstly, the cut stimulates production since capitalists are less burdened by the service of debt. Secondly, the negative elasticity of the investment function is determined by direct and indirect substitution mechanisms: when the interest rate goes down, entrepreneurs tend to increase the capital-labour ratio of their production process to save on the factor become *costlier* – i.e. labour; in addition

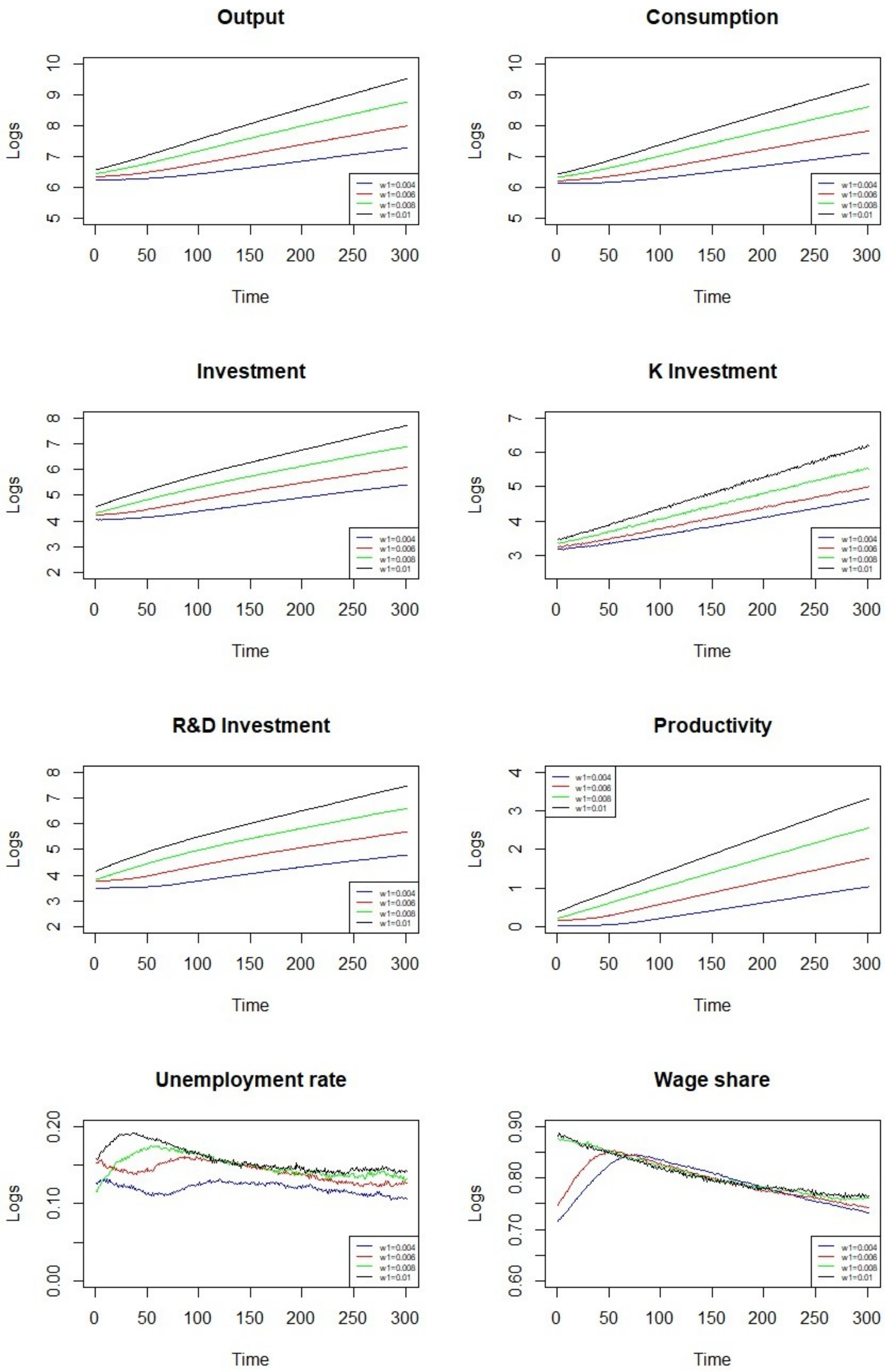


Figure 3.10. Experiments on income distribution

to this, relative prices of more *capital-intensive* goods decrease, augmenting the previous argument. Therefore, the overall demand for capital increases (Girardi, 2016; Petri, 2004). To sum up, the neoclassical argument expects positive effects either on growth performance and innovation rates after a decline in the interest rate. However and in line with Girardi (2016) and Petri (2004), I did not assume that the rate of interest directly influences investment decisions. Yet, there are several channels through which the interest rate can affect investment and the economic performance. On the one hand, the interest rate directly determines the amount of entrepreneurial profits through the interest payments on past loans; in this way, the interest rate shrinks more, or less, the absolute amount of resources capitalists can re-invest in innovation and capital accumulation; moreover, the consumption out of entrepreneurial profits lessens for the same reason. On the other hand, the higher the rate charged on new loans, the higher the bank profits: a greater amount of the latter then accumulates over households deposits with the corresponding increase of their consumption out of wealth. Through this way, higher interest rates could positively affect the overall performance in the economic system. Figs. 3.11 and 3.12 depict the effect of several scenarios with varying interest rates. The interest rate has non-linear and small effect on the level of economic activity. The very non-linearity in the investment pattern arises because of the contrasting movement that the rate of interest spurs on consumption and innovative activity. On the one hand, the entrepreneurs feel less burdened by interest payments so a greater amount of resources accrue to their profits. They are enabled to consume more in absolute terms, and the increase in the latter feeds production and employment. On the other hand, higher profits increase the profit rate and the discrepancy with the target rate shrinks. Moreover, the fear for competition seems attenuated: why should capitalists mechanize production further? Looking at aggregate investment, the non-linearity along monotonic decreases in the rate of interest reflects the different balancing between the increase of aggregate demand on the one side and the lessened need of innovative investment on the other. So we can say that even if the economy seems to perform better in terms of aggregate production and employment, this performance is reached at the expense of technological progress and innovation rates.[14]

Among the several admissible causes of Secular Stagnation in the USA, the experiments

[14] It is worth reminding that the model does not take into account the negative effect on consumption via household debt, which is a crucial feature of US economy. I have already justified my choice on why I did not deepen such a channel; however, I will focus on it in a future research.

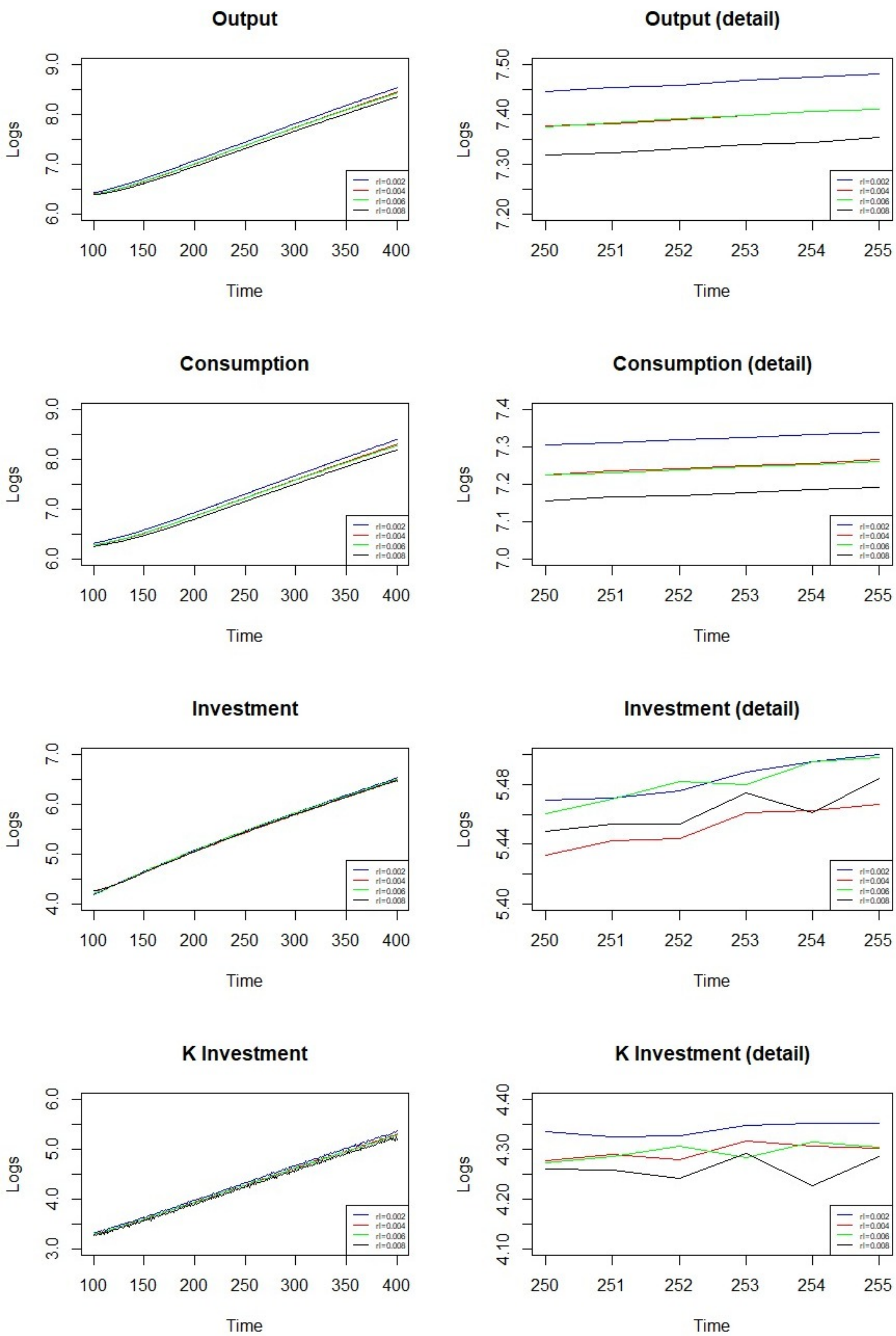


Figure 3.11. Experiments on the interest rate

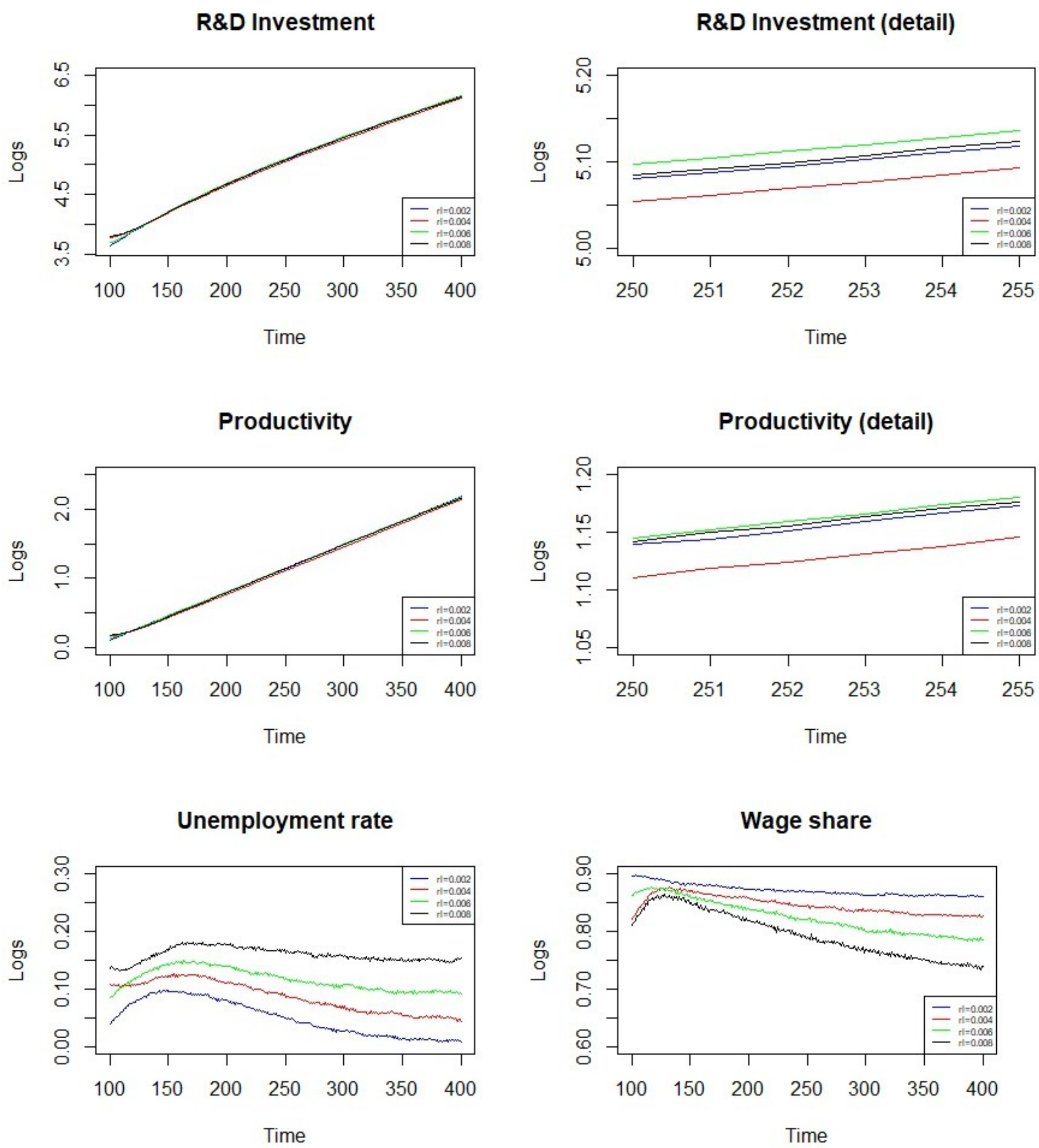


Figure 3.12. Experiments on the interest rate

help me single out also two important processes that have likely contributed to. The experiments help me to frame and explain Secular Stagnation in the USA as the outcome of two important processes. First, social compromises more favourable to capital owners and the strong dejection of pro-labour reforms as witnessed by the American economy resulted in strictly lower incentive to invest on innovative activities, and the economy experienced a retardation in the growth rates of output and labour productivity. Indeed, innovative investments measured by the amount of R&D expenditure financed by private industries has drastically declined in growth terms since the end of the Golden Age of capitalism, as I showed in Part I.[15] At the same time, lower rates of interest do not seem to be effective in triggering investments in R&D or in physical capital, thus questioning the very effectiveness of monetary policies that keep the interest rate down to very low values. The next Section tries to find empirical evidence of these predictions through a simple econometric analysis on US manufacturing industries.

3.5 Empirical analysis

Once the model is developed and assessed through some experiment it is interesting to find empirical evidence, if any, of theoretical results. It is worth establishing since the beginning that what follows does not aim to provide exhaustive results. I instead want to look at the data and check whether my conclusions on the influence of labour costs and interest rates on the innovative effort may be reasonable. In so doing, I shall split the Section into three parts: I start with a description of the data I am going to use; then I dedicate a subsection to the relationship between innovative search and labour costs and another one for the link between innovation and interest rates. The first empirical check involves a panel cointegration analysis in the line of Kao and Chiang (2001); Kao et al. (1999), Phillips and Moon (2000) and Pedroni (2001, 2004); by contrast, the interplay between innovation and rates of interest is detected through simple descriptive statistics only, because of the lack of any good specification for that.

3.5.1 Data

I focus on a yearly panel dataset of fourteen ISIC-based manufacturing industries that represent the full manufacturing sector in the United States over the period 1958 – 2011. Variables at my disposal concern to R&D expenditure, wages paid to production workers, value of shipments, labour productivity, and two different but close measures for the interest rate: effective

[15] The same holds for public investment as well, but I reserve to study that issue in future research. Anyway, the interested reader can refer to Deleidi and Mazzucato (2020) and Pallante et al. (2020).

ISIC Rev.4	Industry
10 – 12	Food, beverages and tobacco
13 – 15	Textiles, wearing apparel, leather and related products
16	Wood and related products
17	Paper and related products
18	Printing and reproduction of recorded media
19	Coke and refined petroleum products
20 – 21	Chemical and pharmaceutical products
22 – 23	Rubber, plastics and other non-metallic products
24	Basic metals
25	Fabricated metals
26 – 27	Electronic and electrical equipment
28	Machinery equipment
29 – 30	Transport equipment
31 – 33	Furniture and miscellaneous manufacturing

Table 3.6. List of manufacturing industries

federal funds rate and bank prime loan rate. While many statistics are straightforward and *easily* available from international sources, the same does not hold for R&D funds; therefore it is worth spending some words on how to get that measure.

The OECD's Anberd database provides data on R&D activities carried out by the business sector and regardless of the origin of funding. The unit of analysis is disaggregated across a hundred of manufacturing and service industries since 1987. However, the long-run character of the analysis prefers a larger time span; thus I have to cover a period that goes back to the late Fifties at least. The NSF's Survey of Industrial Research and Development – SIRD, now BERD – is the natural candidate. SIRD was the primary source of information on R&D expenditures for profit-seeking, publicly or privately held companies with ten or more employees in the US.[16] Moreover, data are clustered and provided at two digit or industry level, not at firm level. SIRD data allowed to enlarge R&D time series back to 1958.

A further problem may be the compatibility between the old US SIC system and the current OECD ISIC classification. I solved that through a scrupulous process of aggregation and check between the different sources. Precisely, I compared the overlapping time span to verify whether SIRD and Anberd gave the same value for a given industry in a given year. Yet, the compatibility need leaves me with a narrow, though comprehensive, cross-section sample, as in Tab. 3.6.[17]

[16] A company is broadly defined as one or more establishments under common domestic ownership or control.

[17] For any issues or curiosities about SIRD and Anberd surveys, I suggest consulting the related documentation available at `https://www.nsf.gov/statistics/srvyberd/prior-descriptions/overview-sird.cfm` and `http://www.oecd.org/innovation/inno/anberdanalyticalbusinessenterpriseresearchanddevelopmentdatabase.htm`, respectively. Moreover, I applied the same procedure for my covariates as well.

Variable	Label	Obs	Mean	Sd	Min	Max
R&D expenditure	rd	634	5589.518	21881.55	5.01961	318768
Wage rate	w	756	8.55767	15.65058	0.45845	177.2766
Value of shipments	s	756	139852	294536.1	4103.765	3954613
Labour productivity	lp	488	239.3435	879.8563	2.739767	16890.46
Effective federal funds rate	effr	756	0.0553454	0.0335722	0.00095	0.1551
Bank prime loan rate	bplr	756	0.0753165	0.0316482	0.0325	0.1887

Note: values are expressed in millions of 2010 dollars. Sources: author's own computations on OECD Anberd database, NSF SIRD survey, FRED St. Louis Fed, NBER Manufacturing Productivity Database.

Table 3.7. Dataset - descritive statistics

Wages, values of shipments, and labour productivity data come directly from the NBER Manufacturing Productivity Database developed by Bartelsman and Gray, among the others. Wages are computed as the ratio between production worker wage bill and number of production worker hours; so it is a measure of hourly wage rate. In contrast, value of industry shipments are based on net selling values after discounts and allowances, and they include receipts for contract work and miscellaneous service provided by a given plant to other (Bartelsman and Gray, 1996); labour productivity is computed as real value added over production working hours.[18]

Last two variables are the effective federal funds rate and the bank prime loan rate. The former is the interest rate at which depository institutions trade federal funds, i.e. balances held at FED banks, with each other overnight. The latter is the interest rate that commercial banks charge to their most creditworthy customers. Data and previous definition are from the FRED St. Louis Fed series. Tab. 3.7 provide some statistics on the variables of interest.[19]

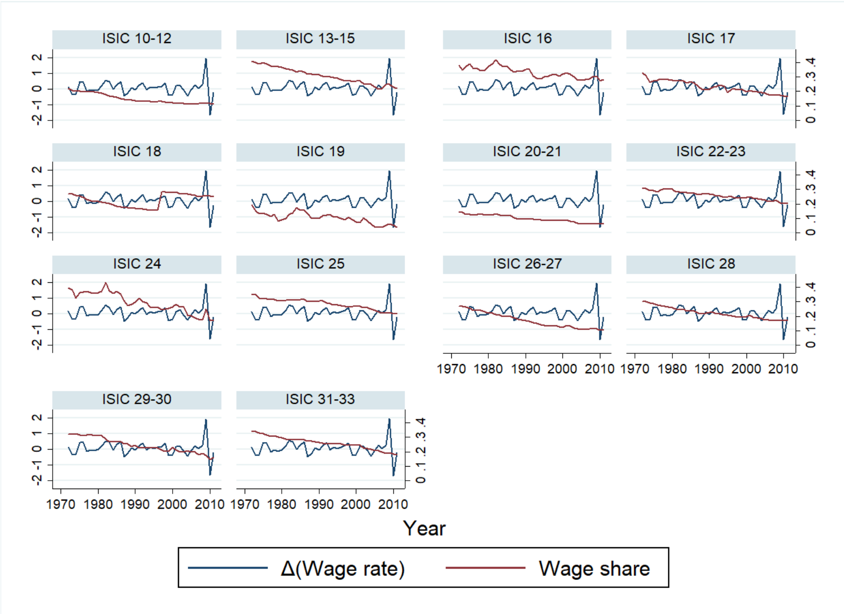
3.5.2 Estimation results: R&D and labour costs.

A clear result from the ACE model above is that wages sustain the demand for consumption commodities, on the one hand, and innovative investments on the other. Entrepreneurs invest in physical capital to enlarge the stock and not to lose clients, and at the same time they will be forced to introduce labour-saving innovations. The need to counterbalance the increase in the labour cost with the introduction of enhancing-productivity techniques is essential to reduce the unit price. This is crucial for their competitive position in the market.

I figure the problem of Secular Stagnation in the USA as due even to a progressive shift of income and bargaining power from labour to capital, that resulted in a smaller incentive to undertake innovative effort, among the other plausible rationales. The steady negative pattern

[18] Please refer to Bartelsman and Gray (1996) for any kind of issues and curiosities on the NBER database.

[19] Every variable has been deflated with the GDP implicit price deflator, so to get real terms. I did not deflate interest rates.



Note: author's own calculations on Anberd and NBER Manufacturing Productivity databases.

Figure 3.13. Wage rate and wage share across US manufacturing industries, 1972 – 2011

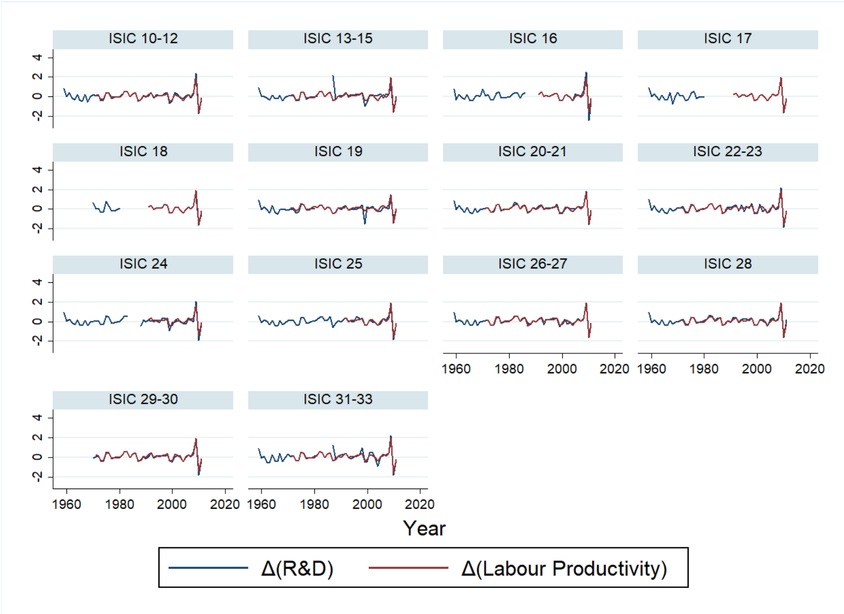
of R&D and wage growth or wage share at the industrial level is clearly visible in Figs. 3.13 and 3.14 since 1972, i.e. the period I identified as Secular Stagnation; the same holds for industry-level productivity growth.[20]

I ascertain we can frame R&D investments at the industrial level as (positive) function of a *cost* component and a *revenue* component:

$$R\&D = f\,(wages; shipments) \qquad f_w, f_s > 0 \tag{3.7}$$

in which f_w and f_s represent first derivative with respect to wages and shipments. The aim is to check whether this theoretical long-run relationship holds on the empirical ground. Several econometric techniques that rely on panel analysis are available to estimate this relation. In particular, the large temporal dimension at disposal suggests implementing the panel time-series analysis as in Pesaran et al. (1999), Phillips and Moon (2000) and Kao and Chiang (2001)

[20] The wage share at the industrial level has been computed as wage bill over value added. Moreover, regressions that show steady negative trends are available upon request.



Note: author's own calculations on Anberd, NBER Manufacturing Productivity and NSF SIRD databases.

Figure 3.14. R&D and labour productivity across US manufacturing industries, 1972 – 2011

among the others. For the sake of simplicity, I shall assume a long-period relation of the form:

$$
\begin{aligned}
rd_{it} = \beta_{0,t} + \beta_{1,t} w_{i,t} + \beta_{2,t} s_{i,t} + \beta_{3,t} d73 w_{i,t} + \\
+ \beta_{4,t} d07 w_{i,t} + \beta_{5,t} d73 s_{i,t} + \beta_{6,t} d07 s_{i,t} + \mu_i + \varepsilon_{i,t}
\end{aligned}
\tag{3.8}
$$

where $i = 1, \ldots, N$ is the number of manufacturing industries; $t = 1, \ldots, T$ the number of periods; rd the log of real R&D expenditure; s the log of real value of shipments; w the log of real wage rate; $d73$ and $d07$ are dummies that account for any structural change occurred in 1973 and 2007, respectively. I choose these dates because it is licit to suspect a structural change in the relationship between regressors, due to the oil shock in 1973 and the strong financial crisis in 2007. Moreover, I define Secular Stagnation as a period started precisely between 1972 and 1973. The corresponding interaction terms with the regressors help me detect the presence of any regime switch in the long-run relation with the dependent variable. Finally, μ is group-specific effect whereas ε a disturbance term independently distributed across i and t.

The econometric procedure involves three steps. Firstly, the long time span rises the problem of unit-roots in the series: I have to test whether innovation investments, wages and shipments are stationary or not. Tab. 3.8 reports to the results of four specific tests for panel data. The LLC test assumes the presence of a common unit root process in the null hypothesis,

	R&D	Wage	Adjusted Wage	Shipments
LLC	−0.4415	−1.5344	2.1876	−1.0927
	(0.3294)	(0.0625)	(0.9856)	(0.1373)
IPS	1.9607	0.2908	6.1719	0.5879
	(0.9750)	(0.6144)	(1.000)	(0.7217)
ADF - Fisher χ^2	13.7763	16.9224	5.4676	16.4977
	(0.9887)	(0.9501)	(1.000)	(0.9578)
PP - Fisher χ^2	13.5362	16.7784	5.0658	15.0528
	(0.9902)	(0.9528)	(1.000)	(0.9779)

Note: panel unit root tests consider individual effects as exogenous variables and I adopt the Schwarz-Bayesian criterion to select the optimal lag length. The null hypothesis assumes a *common* unit root process in the LLC test, while *individual* unit root process in the others.

Table 3.8. Panel unit root tests

while the others are less restrictive and suppose an individual unit root process. All but the LLC test – the latter only with reference to wages – agree on assessing the three variables of interest as nonstationary processes.[21]

Secondly, I have to establish whether any cointegrating relationship exists between them. Cointegration is the condition required for the regression of y on X regressors not to be spurious, i.e. for $\hat{\beta}$ to be consistent for the true value β. If y and X are $I(1)$, then the disturbance u is $I(0)$ and it does not *swamp* the signal. Through cointegration, y and X have a common stochastic trend which is removed by linear combination (Fuertes, 2016). It is worth emphasizing that panel data spurious regression estimates provide a consistent estimate of the true value of the parameter for $N, T \rightarrow \infty$. This characteristic is in sharp contrast with the pure time-series case because panel estimators average out across cross-sections and the information leads to stronger overall signal. For further details, check Pesaran and Smith (1995) and Baltagi (2008). Tab. 3.9 shows the results of seven different panel cointegration tests. They all refer to Pedroni (2001, 2004), which proposed multiple tests for the null hypothesis of no cointegration in nonstationary panels that admit for heterogeneity among cross-sectional relationships. The seven statistics I report point out the degree of evidence, of lack thereof, for cointegration in panels among some variables.[22] Through rejecting the null in all the specifications, results seem to agree that variables are cointegrated, so there exists at least a long-period relationship that tie them.

[21] Interestingly, Fleissig and Strauss (1997) applied the LLC test on real wage panel data finding that real wage innovations for the G7 countries, except for the US, are temporary with half-lives generally less than three years.
[22] I have to admit that the relative power of each test and the theoretical intuition behind them are not very straightforward. Still, check Baltagi (2008) for further insights on that problem.

	Statistic	(Weigthed) Statistic
Panel v-stat	3.6834***	1.9165**
Panel ϱ-stat	−6.6651***	−2.0218**
Panel PP-stat	−8.1807***	−3.0154***
Panel ADF-stat	−7.7646***	−2.9305***
Group ϱ-stat	−3.7770***	
Group PP-stat	−6.4648***	
Group ADF-stat	−7.1560***	

Note: results refer to Pedroni residual cointegration tests where the null hypothesis is of no cointegration; I assume no deterministic trend and I adopt the Schwarz-Bayesian criterion to select the best lag length. Star significance: $^{***}p < 0.01$, $^{**}p < 0.05$ and $^{*}p < 0.1$.

Table 3.9. Panel cointegration tests

Thirdly, last step is about estimation. I have three estimators at my disposal: the pooled mean group (PMG) estimator, the fully-modified least-squares (FOLS) estimator and the dynamic least-squares (DOLS) estimator. The first was developed by Pesaran et al. (1999) as an intermediate technique between the mean group estimator and the standard fixed-effect one. Developers argue that long-period relationship among variables can be the same across groups, while allowing short-run influences and variances to vary over them. It is a maximum-likelihood type estimator which, however, considers regressors as strictly exogenous. In this setting, yet, I cannot exclude causality runs in both the directions.[23]

The second estimator (FOLS) implements a correction that clears out any problem due to long-run correlation between cointegrating equation and stochastic regressor's innovations; the resulting estimator is asymptotically unbiased and has fully efficient mixed-normal asymptotics. FOLS estimator accounts for endogeneity of the regressors, and correlation and heteroskedasticity of the residuals (Phillips and Moon, 2000). I shall nonetheless emphasize that FOLS estimator is subject to asymptotic bias regardless of how individual effects and deterministic regressors are contained if the regressors are nearly rather than exactly unit root processes (Baltagi, 2008). In this case, the DOLS estimator looks more promising.

Finally, the DOLS estimator involves augmenting the cointegrating regression through adding

[23] Rafferty and Funk* (2004) argue nonetheless that shipments, meant as proxies for demand, can be consider as (weakly) exogenous. The advantage of this demand variable over the other proxies for sales is that the latter are an endogenous mixture of supply and demand forces, while shipments is an exogenous mixture of the current and future demand firms *observe* and consider when deciding R&D budgets. We must handle this belief with caution anyway: that sentence may hold in the short term, but it is well plausible shipments are influenced by successful R&D in the longer run.

Dependent variable: R&D	PMG		FOLS		DOLS	
	Model I	Model II	Model III	Model IV	Model V	Model VI
w	0.7195***	0.7849***	0.8538***	0.8123***	0.7836***	0.3299
	(0.1105)	(0.1238)	(0.1207)	(0.1609)	(0.1424)	(0.2989)
s	0.2728***	0.1562	0.1968	0.2446**	0.2449*	0.6007**
	(0.1084)	(0.1081)	(0.123)	(0.1249)	(0.1422)	(0.2704)
$d73w$		0.1257		−0.0002		0.0993
		(0.0914)		(0.1209)		0.2393
$d07w$		−0.2997**		0.0893		0.0085
		(0.01176)		(0.0907)		(0.1825)
$d73s$		0.0062		−0.0052		0.0097
		(0.0049)		(0.0081)		(0.0140)
$d07s$		0.0715**		0.0292		−0.0178
		(0.0293)		(0.0224)		0.1098
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Speed of adj, φ	−0.4320***	0.4319***				
	(0.0778)	(0.0844)				
Log likelihood	426.2998	481.2157				
Observations	606	606	622	622	619	622
Periods	53	53	53	53	53	53
Cross-sections	14	14	14	14	14	14

Note: the wage variable is not adjusted by productivity. The careful reader notices the lack of any measure of goodness of fit and the like. I should exercise extreme caution in using these measures because all of them would be computed using the original and not transformed data. For what concerns the choice of leads and lags, I adopted the Schwarz-Bayesian criterion. I control the short-run dynamics with equipment and structures in every regression; additionally I choose the *pooled* panel method for each specification but in Model VI, in which I opted for the *grouped* to avoid cross-section dropouts. Star significance: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 3.10. Estimation results

lags and leads of the regressors first differences, so to wash away asymptotic endogeneity and serial correlation.

Tab. 3.10 presents the outputs of the regressions based on (3.8). I carry out two different models for each chosen estimator. *Odd*-number models do not take into consideration possible changes in the long-run relations between dependent variables and regressors, captured by the interaction of dummies and covariates. By contrast, *even*-number models do.[24]

We grab first that the revenue component identified with shipments exerts positive but not always significant effect on the total amount of R&D expenditure. Precisely, a 1% increase in the value of real shipments leads from 0.2 to 0.6% increase in the R&D spending at industrial level, depending on the specification. Additionally, the interaction terms do not turn out to be very relevant, being the exception represented by Model II, in which the parameter associated with $d07s$ clearly shows that the long-run relationship between R&D and shipments has changed and reinforced significantly since 2007. In contrast, for what concerns the cost component, that is hourly wages, results are more uniform: in particular, a 1% increase in the wage rate leads from 0.7 to 0.8% increase in R&D funds when significantly different from zero.[25]

[24] Capital stock in the form of equipment and plants is used as control in every regression; both are from the aforementioned NBER database.

[25] Even though Pedroni tests found cointegrating relationship, it is always worth checking if the estimated residuals

I have nonetheless to signal a caveat: I did not consider the fact that entrepreneurs may not have any reason to undertake innovative investments if productivity simply increases with wages. I therefore repeat the estimations adjusting wages through productivity; it works as a robustness check too. Results are displayed in Tab. 3.11 and look quantitatively but not qualitatively different from the above. The expected sign of our coefficients of interest are indeed positive and statistically significant in most cases. Additionally, the interaction terms turn out to be relevant in the majority of the models. Adding interaction terms indeed drastically changes the interpretation of the coefficients: for example $\hat{\beta}_2$ cannot be interpreted as the unique effect of shipments on R&D anymore. The same holds later for labour costs.
Precisely, I can say that whatever specification we observe, the revenue component exerts a positive and significant effect of the dependent variable: a 1% increase on that leads to a 1% increase in R&D spending at the industrial level. In contrast, results are less uniform for what regards to my measure of unit labour costs. The PMG and the DOLS estimations without interaction terms finds no significant relationship between R&D and labour cost, while FOLS estimate does. However, including interaction variables allows me to argue that a 1% increase in the adjusted wage rate is accompanied roughly to a 0.5% increase in R&D funds, at least and when significant. The significance of the coefficients related to the interactive terms shows that the relationship changes through time, especially after 2007.[26]

All in all, I find empirical evidence of prior theoretical results, in that either the *cost* component and the *revenue* component are positively related with expenditures on R&D with respect to the US manufacturing industries since 1958. Results are qualitatively robust to whether we adjust hourly wages with hourly labour productivity. Next step involves the analysis of the relation between R&D and the interest rate, which is going to be set through simple descriptive statistics for the reasons below.

are stationary processes. I applied panel unit root tests for them and I found that they are actually stationary. Results available upon request.

[26]In Model VI I applied the grouped panel method as in Pedroni (2001, 2004). Moreover, the residual diagnostics in each regression shows that residuals are $I(0)$ processes, so I have not the problem of spurious results, though I previously wrote that spurious regressions are not such a huge problem in panel econometrics.

Dependent variable: R&D	PMG		FOLS		DOLS	
	Model I	Model II	Model III	Model IV	Model V	Model VI
w_{adj}	0.2624	1.1128***	0.5202***	0.4709*	0.3226	3.4086*
	(0.2264)	(0.3331)	(1.0264)	(0.2802)	(0.2530)	(1.9437)
s	1.0232***	0.9458***	1.0264***	0.9599***	1.0244***	1.4508***
	(0.0305)	(0.0391)	(0.0350)	(0.0433)	(0.0000)	(0.2138)
$d73w_{adj}$		0.0436		0.4807**		−3.1643
		(0.2769)		(0.2291)		(1.9565)
$d07w_{adj}$		0.5039**		0.3711***		1.1510*
		(0.2553)		(0.1452)		(0.6234)
$d73s$		0.0227		0.0582*		−0.4852**
		(0.0377)		(0.0321)		(0.2197)
$d07s$		0.0915***		0.0787***		0.1170
		(0.0331)		(0.0221)		(0.0800)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Speed of adj, φ	−0.4150***	−0.4182***				
	(0.0986)	(0.1006)				
Log likelihood	382.8508	433.3805				
Observations	606	606	622	622	616	622
Periods	53	53	53	53	53	53
Cross-sections	14	14	14	14	14	14

Note: the wage variable is adjusted by productivity. The careful reader notices the lack of any measure of goodness of fit and the like. I should exercise extreme caution in using these measures because all of them would be computed using the original and not transformed data. For what concerns the choice of leads and lags, I adopted the Schwarz-Bayesian criterion. I control the short-run dynamics with equipment and structures in every regression; additionally I choose the *pooled* panel method for each specification but in Model VI, in which I opted for the *grouped* to avoid cross-section dropouts. Star significance: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 3.11. Estimation results: robustness check

3.5.3 Estimation results: R&D and interest rates.

To investigate the relationship between innovative search and the rate of interest is somehow complicate. I have found more appropriate not to include the interest rate among the direct determinant of R&D investments because of the theoretical reasons above. However, as we have discussed, there may still be room for some indirect effects. What I grasp from the previous Section is that the interest rate has a non-linear and small effect upon innovation efforts and on the overall level of economic activity. The very non-linearity in the R&D pattern arises because of the contrasting movement between the revenue and the cost components. On the one hand, capitalists increase the consumption in absolute terms because more profits accrue to their pockets and their need to innovate rises; but on the other hand, they are less afraid of the competitive pressure and reach a normal profit rate more easily, so the necessity to seek for labour-saving techniques looks reduced.

From an empirical point of view, I cannot handle the non-linearity, or to find evidence of it, by simply posing a quadratic or more complex specification in a standard regression model. All of them would be econometric mis-specifications, since I could not detect a well-established or predictable form from previous simulations. Fig. 3.12 shows indeed that different but close values of the rate of interest determine different schedules in the innovation pattern of the economy, and I am not able to foresee what could be the effect of an increase in

	R&D - effr		R&D - bplr	
	Statistics	(Weighted) Statistic	Statistics	(Weighted) Statistic
Panel v-stat	−1.5239	−1.6006	−1.9609	−1.9631
Panel ϱ-stat	0.2014	0.2013	1.7243	1.7355
Panel PP-stat	−0.6616	−0.7286	1.2104	1.1888
Panel ADF-stat	−0.5265	−0.3897	1.5646	1.7473
Group ϱ-stat	1.7623		3.0944	
Group PP-stat	0.0297		2.1218	
Group ADF-stat	0.1082		2.5287	

Note: results refer to Pedroni residual cointegration tests where the null hypothesis is of no cointegration; I assume no deterministic trend and I adopt the Schwarz-Bayesian criterion to select the best lag length. Star significance: $^{***}p < 0.01$, $^{**}p < 0.05$ and $^{*}p < 0.1$.

Table 3.12. R&D and interest rates: Pedroni panel cointegration tests

the interest rate, as tiny it might be. A straightforward connection between the two probably does not exist. Although I do not suggest or assume any specific relationship between them, I can still perform an econometric cointegration test to see whether any long-run meaningful relation actually exists. Tab. 3.12 shows the results of Pedroni residual cointegration tests. In particular, I test the existence of a long-run relationship between R&D investment and the funds rate, on the one hand, and with the prime rate, on the other hand. I obtain the interesting result that no long-run linkage exists between innovative search and the interest rate, whatever measure I choose for the latter. It means that any estimated regression of the former on the latter would provide me with spurious coefficients.[27]

Because of that, I have decided to set any econometric and parametric analysis aside, and plot a few descriptive statistics only. Figs. 3.15 through 3.18 display different ways of conceiving the time-evolution of R&D and interest rate. The first way is to compute the ratio between the level first – and the growth rate later – of R&D spending and the bank prime loan rate. For what regards to the ratio between R&D in levels and prime rate, it fluctuates around a slightly increasing average trend, while the ratio that considers the R&D growth rates in the numerator swings around a trendless average. These results are clear especially for the cross-sections not affected by missing data.

Another way to check the behaviour of these variables is to plot R&D against the prime rate. This method looks closer to the results of the model, in which simple jumps in the rate value prompt change in the innovation pattern. And apparently that is what we see from Fig. 3.16: different values in the prime rate are associated with different growth rates of R&D. Additionally, they do fluctuate around a flat zero mean. Finally, Figs. 3.17 and 3.18 repeat

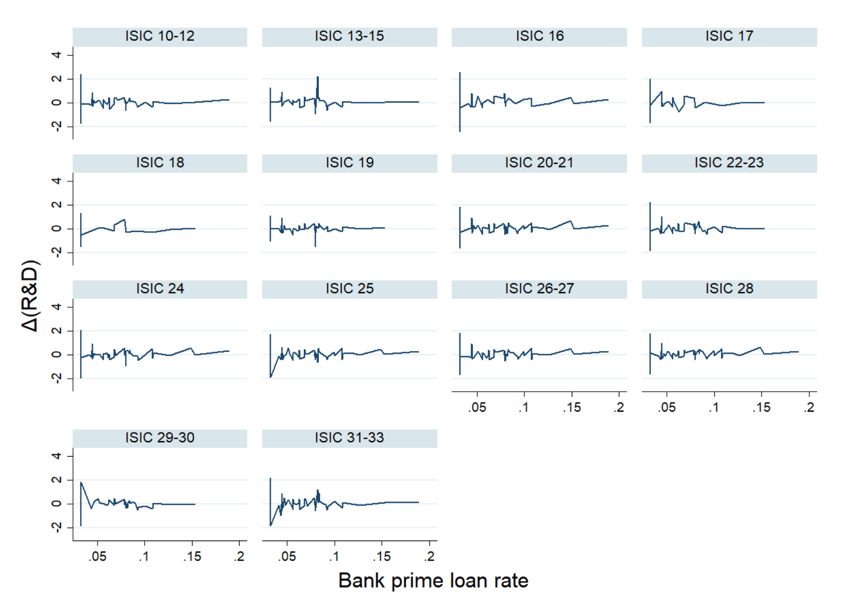
[27] I computed also a simple correlation coefficient with the data at disposal and the value was very small, 0.0444, not statistically significant from zero.

Note: author's own calculations on Anberd, FRED St. Louis and NSF SIRD databases.

Figure 3.15. Ratio between R&D and bank prime loan rate across US manufacturing industries, 1958 – 2011

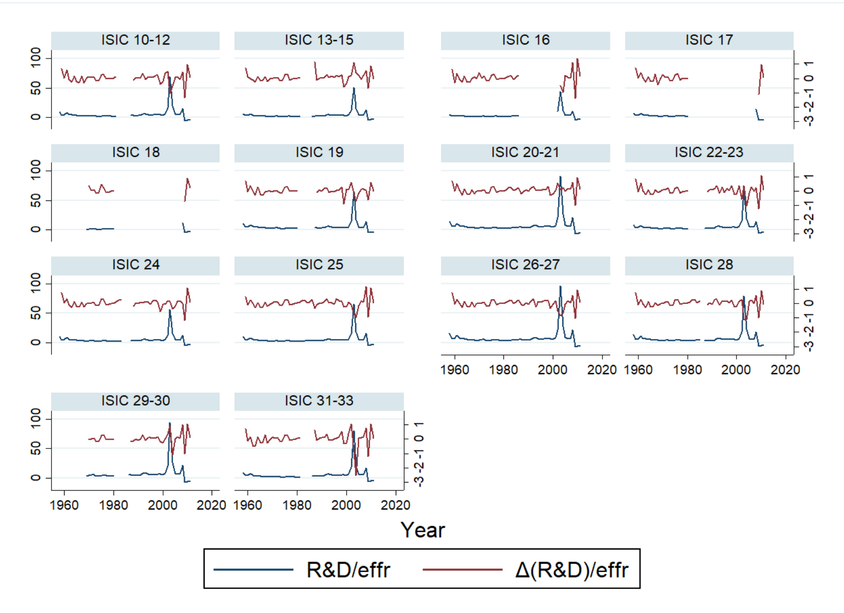
the same exercises using the funds rate in the place of the prime rate; results do not change significantly.

I conclude this Section with a little recap. Among the plausible explanations for Secular Stagnation in the USA, I emphasized the negative effect that the shift of income and bargaining power from wage-earners to profit-earners led to a reduction in the growth rate of R&D investments. The simplest argument ran as follows: a low bargaining power of employees and their labour unions, as experienced since the early Seventies, will stop the increase in nominal and real wages, that will finally generate a rising profit share and hence a lower wage share. That will decelerate firms' efforts to improve productivity growth through innovation, because there is no decrease in the profit share to prevent (Hein, 2012). I tested this theoretical implication at the empirical level, focusing on a panel of US manufacturing industries from 1958 to 2011. I adopted different panel cointegration techniques and found that a positive relationship between labour costs and innovation rates generally holds since 1958, with some exception notwithstanding. It contributes to explain the decline in productivity growth, as Secular Stagnation is identified through this work, also by the negative influence exerted by the diminished wage share on firm's innovative search. Moreover, this linkage tends to strengthen since the



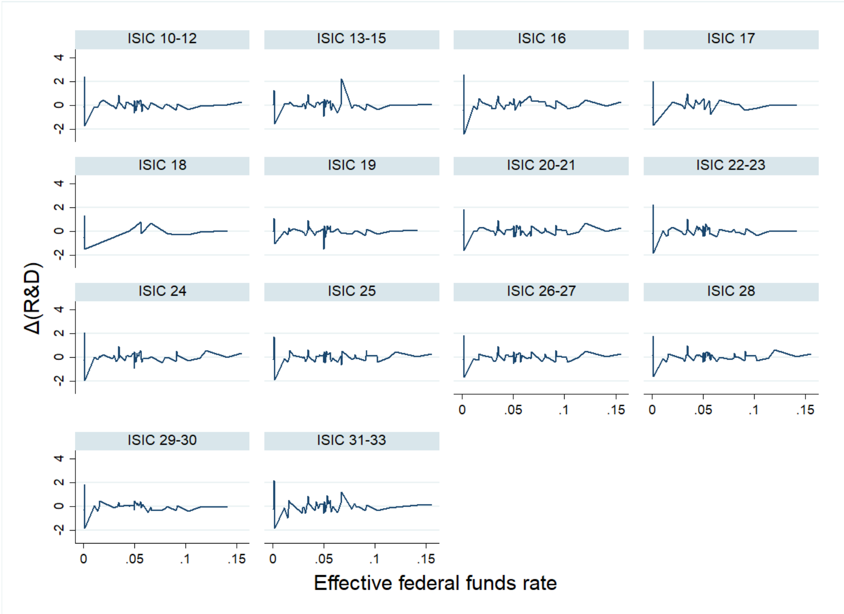
Note: author's own calculations on Anberd, FRED St. Louis and NSF SIRD databases.

Figure 3.16. R&D against bank prime loan rate across US manufacturing industries, 1958 – 2011



Note: author's own calculations on Anberd, FRED St. Louis and NSF SIRD databases.

Figure 3.17. Ratio between R&D and effective federal funds rate across US manufacturing industries, 1958 – 2011



Note: author's own calculations on Anberd, FRED St. Louis and NSF SIRD databases.

Figure 3.18. R&D against effective federal funds rate across US manufacturing industries, 1958 – 2011

Seventies, i.e. the period in which I set the theoretical onset of Secular Stagnation, and after the crisis of 2007.

In a second exercise, I detected the existence of any relationship between R&D and interest rates through a basic descriptive line, but I did not find any clear or well-established interplay between them. Moreover, panel cointegration tests do not allow me to reject the null hypothesis of no cointegration in each specification. This result again does not conflict with my theoretical arguments but deserves further research.

3.6 Conclusions

The aim of Part II was to extend research started with Part I. I studied the problem of Secular Stagnation in the United States, arisen since the early Seventies as a long-run slowdown in the growth rates of productivity, that reached the trough with the Great Recession of 2007. I developed a complex, adaptive and structural ACE growth model in the line of Dosi et al. (2010), Caiani et al. (2016a), Tesfatsion (2006), among the others. The ability of the model to satisfy some empirical regularity in terms of firm size distribution, productivity heterogeneity, investment lumpiness, among the other facts, helped me strengthen my theoretical results in terms of policy implications. I investigated the nexus between income distribution and firm's effort to invest on innovative search. I concluded that a low bargaining power of employees

and their labour unions, as experienced since the early Seventies, contained the growth of nominal and real wages, that finally generated a rising profit share; firms' effort to improve productivity growth through the introduction of new labour-saving innovations diminished accordingly, since there was no decrease in the capital income share to prevent.
Furthermore, I addressed the neoclassical belief about the negative interest-elasticity of the investment function, since my model showed that decreases in the interest rate on loans were not associated with any surge in capital accumulation. They did instead lead to non-linear and unpredictable effects.
Finally, I carried out a simple empirical analysis for the main theoretical achievements. The focus was on US manufacturing industries from 1958 to 2011. I found empirical evidence confirming my suggestions, with some exception notwithstanding. On the one hand, I found robust empirical evidence of a positive long-period relationship between innovative effort and (unit) labour costs at the industrial level; in addition to this, the positive effect was statistically significant in most specifications. On the other hand, panel cointegration tests led me to claim the lack of any clear and well-established long-run linkage between innovative activity and the rate of interest, the latter measured with the effective federal funds rate or the bank prime loan rate. Obviously, I am not in the position to argue that my explanations for Secular Stagnation in the USA are the only valid rationales. Many other reasons such as the rise of superstar firms or the growing trade with Chinese manufacturing can provide useful information to explain the falling pattern of productivity growth.

In this respect, future research will enlarge the analysis on Secular Stagnation in the USA through the introduction of five issues at least. Firstly, I will shift from functional to personal distribution of income. The introduction of heterogeneous workers in terms of productivity and earnings looks appropriate to explain a further channel through which income inequality may have contributed to the rise of Secular Stagnation in the USA. The framework in Ciarli et al. (2010, 2019) and Lorentz et al. (2016), in which inequality endogenously arises out of the increase in the number of *tiers* and income classes, seems a promising avenue for my purpose. Secondly, I would like to remove some of the most restrictive assumptions I accepted thus far, and differentiate between a capital good sector and a consumption good sector. The capital good sector performs R&D and sell new technological vintages in the form of capital goods to consumption good firms. In addition to this, the introduction of inventories and a process of entry-exit dynamics can contribute to analyse the rise of superstar firms as a further symptom of Secular Stagnation.

Thirdly, the question of household and corporate debt: although the very restrictive assumption I made about bank *passive-ness* is not uncommon (Deissenberg et al., 2008), a huge amount of literature pinpoints the role of private debt and banks lending activity in shaping US business fluctuations and economic growth. Secular Stagnation, viewed as a productivity and innovation problem, should take debt dynamics into account.

Fourthly, the introduction of a public agent, i.e. Government, is important to explain discoveries, incentives and adoptions of technological opportunities. Mazzucato (2011) clearly showed the impact of public policies on innovation rates with special reference to the United States.

Finally, the econometric analysis has considered manufacturing industries only. I want to further deepen my study by acquiring firm-level data with respect to either manufacturing or services. Innovation does not occur in manufacturing industries only. A more-in-depth panel analysis may still provide us with further insights on the relationships between firm's innovative effort and income distribution.

Appendix D

Model Recap

This Appendix provides the reader with a quick recap on the equations that constitute the model; there are not major differences with respect to Chapter II. For the sake of convenience, I split the equations in seven groups: production firms, labour market, households and consumption, Schumpeterian innovation, banking system, pricing and inflation expectations, and the closure. I assume no inventories with production fully adapting to demand; in addition to this, output components are expressed at constant prices. The letter j, if not otherwise specified, refers to the single firm.

D.1 Production firms

I write production at firm level as:

$$y_j = c_{f,j} + i_{s,j} + i_{rd,j} \tag{D.1}$$

in which y_j denotes the amount of production which can be split into consumption goods $c_{f,j}$, physical investment $i_{s,j}$ and innovative search $i_{rd,j}$. I adopt the Leontief technology that considers labour and capital as means of production employed in fixed proportions:

$$y_j^P = min\left[\varphi \cdot k_j; a_j \cdot N_s\right] \tag{D.2}$$

in which y_j^P represents firm's productive capacity, k the capital stock, whereas φ_j and a_j are the output-to-capital ratio and the labour productivity within the firm, respectively. A constant proportion δ_j of the existing equipment depreciates every period and capitalists set aside an amount of funds exactly equal to replace the worn-out capital:

$$da_j = \delta \cdot k_{t-1,j} = af_j \tag{D.3}$$

in which da_j and af_j define, respectively, the depreciation allowances and the amortization fund. Firms invest either on physical capital or innovative search: the latter has been already described in (3.5), while the former is a standard accelerator equation, in which the gross expenditure, $i_{k,j}$, encompasses the exogenously-growing animal spirits $i_{0,j}$, the adjustment of capital to the target level $\left(k_j^T - k_j\right)$ and the amortization fund af_j: There is no trade-off between different types of investments. We can instead see these investments as complementary: innovation allows for a reduction in unit price while a greater capital stock permits to satisfy a higher turnout. So, if combined, they both raise total earnings.

$$i_{k,j} = i_{0,j} + i_{1,j} \cdot \left(k_j^T - k_j\right) + af_j \tag{D.4}$$

Entrepreneurial profits, f_j, are a residual claim, i.e sales minus the amortization fund, the interest payments on past loans $int_{ld,j}$, and the wage bill at firm level wb_j:

$$f_j = y_j - af_j - int_{ld,j} - wb_j \tag{D.5}$$

Since every firm orders machines to other firms, I define with $i_{d,j}$ in (D.6) the investment *demand*:

$$i_{d,j} = i_{k,j} + i_{rd,j} \tag{D.6}$$

However, since what the j-th firm demands differs from what is ordered by other firms, I denote with $i_{s,j}$ the amount of investment goods each firm produces for others. For simplicity, it consists of an average amount of physical investments, $\bar{i}_{k,j}$:

$$i_{s,j} = \bar{i}_{k,j} \tag{D.7}$$

The capital stock k_j is the result of past (depreciated) equipment plus gross investment:

$$k_j = (1 - \delta) \cdot k_{t-1,j} + i_{k,j} \tag{D.8}$$

A firm may borrow from the banking sector to fund its investment expenditure; at the same time, it draws funds from previous accumulated profits. The change in loans demand is then:

$$dl_{d,j} = i_{d,j} - af_j - q \cdot m_{h,t-1,j} \tag{D.9}$$

in which, $dl_{d,j}$ is the change in loans demand and q is the share of profits re-invested $m_{h,t-1,j}$ by capitalists.

D.2 Labour market

Firms set labour demand nd_j as the simple ratio between production and effective labour productivity at firm level:

$$nd_j = \frac{y_j}{a_j} \tag{D.10}$$

The wage bill at firm level, wb_j, is the simple product between the wage rate from (3.3) and the number of employees:

$$wb_j = w_r \cdot nd_j \tag{D.11}$$

D.3 Households and consumption

Workers and capitalists consume with propensity $\alpha_{1,i}$ and $\alpha_{2,i}$ out of expected real disposable income, respectively; the propensity to consume out of expected real wealth, $\alpha_{3,i}$, varies only across agents and independently to the status i. Disposable income, ydh_i, is equal to:

$$ydh_i = \begin{cases} w_r + \sigma_{mh,i} \cdot F_{b,t} + int_{mh,i} & \text{if} \quad i \quad \text{is worker} \\ f_i + \sigma_{mh,i} \cdot F_{b,t} + int_{mh,i} & \text{if} \quad i \quad \text{is capitalist} \end{cases} \tag{D.12}$$

The flow of income consists of four components: wage rate, entrepreneurial profits, bank profits proportional to agent's wealth $\sigma_{mh,i} \cdot F_{b,t}$, and interest payments on past deposits $int_{mh,i}$. $\sigma_{mh,i}$ represents the share of total wealth belonging to each household; $F_{b,t}$ is the amount to banking profits as in (D.24). Consumption functions are:

$$c_{inc,i} = \begin{cases} \alpha_0 + \alpha_{1,i} \cdot w_{r,-1} + \alpha_{3,i} \cdot (\sigma_{mh,i} \cdot F_{b,t} + int_{mh,i}) & \text{if} \quad i \quad \text{is worker} \\ \alpha_0 + \alpha_{2,i} \cdot f_{i,-1} + \alpha_{3,i} \cdot (\sigma_{mh,i} \cdot F_{b,t} + int_{mh,i}) & \text{if} \quad i \quad \text{is capitalist} \end{cases} \tag{D.13}$$

$$c_{wea,i} = \alpha_{3,i} \cdot m_{h,-1,i} \tag{D.14}$$

$$c_i = c_{inc,i} + c_{wea,i} \tag{D.15}$$

in which a_0 is a autonomous consumption, c_{inc} is the consumption out of income, c_{wea} the consumption out of wealth and c_i the overall consumption. Savings, $dm_{h,i}$, accumulate to the stock of deposits, $m_{h,i}$:

$$dm_{h,i} = ydh_i - c_i \tag{D.16}$$

$$m_{h,i} = \begin{cases} m_{h,-1,i} + dm_{h,i} & \text{if} \quad i \quad \text{is worker} \\ m_{h,-1,i} + dm_{h,i} - q \cdot m_{h,-1,i} & \text{if} \quad i \quad \text{is capitalist} \end{cases} \tag{D.17}$$

I have re-adapted the mechanism developed in Riccetti et al. (2015), according to which buyers and sellers meet in the market for commodities and act through a simple procurement process: potential customers observe a subset of prices from a narrow and random bunch of producers, as outcome of imperfect information. The *best* seller will be chosen according to the lowest price. Every period the single customer is given the opportunity to break the relationship with the previous trade partner and switch to another producer with a certain probability. I define the latter as:

$$Prob = \begin{cases} 1 - e^{\chi_1 \cdot \frac{p_{new} - p_{old}}{p_{new}}} & \text{if} \quad p_{new} < p_{old} \\ 0 & \text{otherwise} \end{cases} \tag{D.18}$$

The simple probability rule tells me the larger the price differential between the former and the new potential supplier, the higher the probability to select the new. The assumption considers the empirical fact that consumers try to establish a durable relation of trust and reciprocity to solve problems of asymmetric and imperfect information (Bowles, 2009).

D.4 Schumpeterian innovation

Innovation is affected by uncertainty in its *Knightian* form, interpreted as the lack of any quantifiable knowledge about some possible occurrence. Somebody might object the advocacy of Knightian uncertainty as it collides with a model using pseudo-random numbers. Though the pattern generated by this mechanism is based upon randomness, it cannot clearly be *really* random, since any seed produces exactly the same values. Pseudo-random numbers do not replicate Knightian uncertainty. Computers are indeed deterministic machines and cannot produce random values, but can give us series based on algorithms that respect the requirements for randomness. The model is run along many Monte Carlo simulations: attaching a different seed to every single run helps me buffer machine shortcomings. The enterprise has access to several *potential* productivity gains, either through home innovation or from imitation. I identify with a_{jj} the labour productivity in the j-th firm as result of its own innovative search, with a_{ji} the productivity of the j-th firm as outcome from imitation and with a_j the effective productivity in the j-th firm at some point in time; the latter is the maximum between the former. Innovation is a costly process that firms finance part out of new loans and part out of past wealth. To model this process, I select a logistic probability distribution, which is increasing with the cumulative investment on R&D:

$$\lambda_j = \frac{1}{1 + e^{-\varepsilon \Sigma_1^t i_{rd,j}}} \tag{D.19}$$

The sinusoidal function approaches to 1 as long as the cumulative investment augments over time. To ascertain whether innovation actually occurs, a random number is drawn from a uniform distribution. If the drawn number is lower than λ, the entrepreneur successes in innovating and productivity will grow accordingly:

$$a_{jj} = a_{t-1,jj} \cdot e^{g_{ird,-1,j}} \tag{D.20}$$

The imitation process reflects to the above. Entrepreneurs meet a narrow sample of competitors randomly. I exclude free-riders and adopt the law in (D.19) to state that the probability the capitalist has to imitate is a positive function of her cumulative investments. Once the probability to copy fulfills, the innovative entrepreneur has to evaluate which productivity gain is higher and effective productivity is set accordingly:

$$a_j = max \left[a_{jj}; a_{ji}\right] \tag{D.21}$$

The innovation process allows for the emergence of heterogeneity across firms, a *path-dependent* heterogeneity that accounts for firm's ability to learn from past experience and competitors. The *learning* ability is the crucial feature of the ACE and it is a key departure from more standard approaches, since the events are driven by agent interactions only, had the initial conditions been specified (Tesfatsion, 2006).

D.5 Banking system

I suppose the existence of an aggregate big bank that accommodates the demand for loans from the business sector. I further assume any credit constraints away, so the bank provides producers with enough money to cover their investments plans and collects whatever amount of deposits from the public at given interest rates. The equations describing bank behaviour are the following:

$$int_{ld,j} = r_l \cdot \sigma_{ld,j} \cdot L_{d,t-1} \tag{D.22}$$

$$int_{mh,j} = r_h \cdot \sigma_{mh,j} \cdot M_{h,t-1} \tag{D.23}$$

$$F_{b,t} = r_l \cdot L_{d,t-1} - r_h \cdot M_{h,t-1} \tag{D.24}$$

(D.22) defines firm interest payments on loans as share on total loans: r_l is the interest rate charged on loans whereas σ_{ld} is firm's share on aggregate loans; (D.23) reflects how the bank rewards household deposits as share on total wealth: r_h is the interest rate on deposits while M_h is aggregate wealth. Last equation, (D.24), computes banking profits, F_b, that will be redistributed to households in proportion to their stock of wealth.

D.6 Pricing and inflation expectations

Firms set prices as a mark-up over unit labour costs:

$$p_j = (1 + \mu_j) \cdot \frac{w_r}{a_j} \tag{D.25}$$

in which p_j, μ_j, w_r and a_j are, respectively, the unit price, the mark-up, the wage rate and the labour productivity at firm-level. I model the inflation rate as the percentage change in the average price level:

$$\bar{P}_t = \frac{\Sigma_{j=1}^{F}}{F} p_j \tag{D.26}$$

$$\Pi_t = \frac{\bar{P}_t}{\bar{P}_{t-1}} - 1 \tag{D.27}$$

Inflation enters the model through its influences on investment and consumption decisions: the idea is that higher inflation decreases the real value of capital goods and the amount of desired consumption. Furthermore, I adopt a *regressive* inflation-expectations process (Sawyer and Passarella, 2019). I denote the expected inflation rate with Π^e:

$$\Pi^e = \psi_0 + \psi_1 \cdot \left(\Pi^T - \pi_{t-1}\right) + \Pi_{t-1} \tag{D.28}$$

In (D.28) Π^T is the target inflation rate while ψ_0 and ψ_1 are parameters. The expected price level P_t^e is then:

$$P_t^e = (1 + \Pi^e) \cdot \bar{P}_{t-1} \tag{D.29}$$

The final step consists of identifying an inflationary-correcting term to insert into the target-capital and wage functions:

$$PR_t = \frac{P_t^e}{\bar{P}_t} \tag{D.30}$$

D.7 Model closure

Last expression concerns to the *redundant equation*, a relationship that equals the stock of loans, M_s, with the stock of wealth, M_h:

$$M_{h,t} = M_{s,t} \tag{D.31}$$

Although the model contains no equilibrium condition which makes $M_{h,t}$ and $M_{s,t}$ equal, they must result identical once the model is solved, in accordance to a Walrasian principle (Godley and Lavoie, 2006). Tab. D.1 provides information about time span, number of agents, parameter setting and exogenous variables.

Notation	Description	Value
$Time$	Time span	400
MC	Monte Carlo runs	100
F	Firms	40
N_s	Workers-Consumers	600
α_0	Autonomous consumption	0.0075
α_1	Worker's marginal propensity to consume out of income	[0.6; 65]
α_2	Capitalist's marginal propensity to consume out of income	[0.5; 0.55]
α_3	Marginal propensity to consume out of wealth	[0; 0.06]
a_0	Labour-productivity initial value	1
a_1	Coefficient in the productivity equation	0.75
δ	Capital depreciation	0.05
ε	Parameter in the λ function	0.005
i_0	Autonomous investment at $t = t_0$	0.8
i_1	Partial-adjustment coefficient	[0.25; 0.35]
$meet$	Meetings per unit of time	3
μ_0	Mark-up at $t = t_0$	0.075
ψ_0	Coefficient in the price expectations function	0
ψ_1	Coefficient in the price expectations function	0.01
q	Share of wealth re-invested	0.0216
r_l	Interest rate on loans	0.0075
r_h	Interest rate on deposits	0.0025
ϑ_1	Coefficient in the R&D investment growth equation	[0.01; 0.02]
ϑ_2	Coefficient in the R&D investment growth equation	[0.025; 0.035]
v	Coefficient in the mark-up growth equation	0.85
w_0	Wage rate at $t = t_0$	0.5
w_1	Coefficient in the wage growth equation	0.007
w_2	Coefficient in the wage growth equation	0.0045
χ	Consumer's links	5

Note: shaded lines denote variables whose value differs between agents.

Table D.1. Parameter setting for the growth model

Final Considerations

I reminded over and over again that the matter risen by Secular Stagnation theories is far from simple or solved. These pages have tried to show how that problem may turn around to, among other things, two basic words: income distribution. From this point of view, more egalitarian societies, in which the slice of the social product to profits is not so large if compared to the slice for labour, would seem better equipped to cope with the long periods of economic stagnation I have debated on.

However, I would fail if I thought that the problem were economic *only*: are the prescribed policies *politically* feasible? The meltdown in 2007 and the corresponding revival of Secular Stagnationist theories occurred within strong changes in the international relationships and a more general crisis involving political and social aspects of the common life. With respect to the USA, the problem was raised by Prof. Summers during the debate with Prof. Stiglitz on the columns of Project Syndicate in 2018.[1] The diatribe focused on the ineffective and insufficient fiscal stimuli set by the American administration – as Stiglitz judged– the weak positive effect in reducing unemployment notwithstanding. Stiglitz's point was that the government did not pursue a stronger and more flexible fiscal policy. Had the latter better-structured, more designed for the poor and longer, then the recovery would have concerned to a bigger slice of population than top % only. Furthermore, the fiscal stimulus should have launched a massive income re-distribution, the strenghtening of workers's bargaining power and the weakening of agglomeration market power, along with industrial policies to help American de-industrialized areas. Summers replied that, while agreeing with these policy presciptions, a stronger stimulus than what actually took place would have been *politically unfeasible*. It is all but simple therefore to find a good reply to the question above. But something must be done in the direction paved by Stiglitz; at least not to confirm the suggestion by Eco (2004) on good proposals, according to which "the simple folk always pay for all, even for those who speak in their favor".

[1] Stiglitz (2018); Summers and Stiglitz (2018).

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