An Empirical Comparison of Interest and Growth Rates

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Abstract: This paper investigates methods of assessing dynamic efficiency, points out their shortcomings and develops a new criterion of determining whether or not an economy accumulates too much capital. This criterion is then applied to the OECD countries as well as China. The analysis sheds a new light on recent proposals of raising public debt levels during a time of low interest rates.

Keywords: Overaccumulation; dynamic efficiency; public debt; ponzi games; zero lower bound; WACC.

JEL-Classification: E22, E43, O47

Table of Contents

List of Abbreviations II

Introduction 1

Chapter 1: Overaccumulation, Ponzi Games, and an Economy with Land 3

1.1. What is Overaccumulation? 3

1.2. Dynamic Inefficiency in the Diamond Model 6

1.3. Assessing Dynamic Efficiency 11

1.4. Ponzi Games 14

1.5. A Modified Diamond Model – The Introduction of Land 15

Chapter 2: Applying the Theory – Methods of Assessing Dynamic Efficiency 20

2.1. Review of Important Empirical Studies So Far 20

2.2. Determining "The" Interest Rate 26

2.3. Weighted Average Cost of Capital 34

2.4. Summary 36

Chapter 3: An Empirical Test of Dynamic Efficiency 37

3.1. Data Sources and Calculations 39

3.1.1. Growth Rate 39

3.1.2. WACC 40

3.1.3. Interest Rates 44

3.1.4. Combining countries 44

3.2. Results 46

3.2.1. Category I 46

3.2.2. Category II 49

3.2.3. Category III 53

3.2.4. Category IV 54

3.2.5. Summary 56

Chapter 4: Discussion 57

4.1. Are the OECD Countries and China dynamically inefficient? 57

4.2. Limitations and Reliability 65

Concluding Remarks and Outlook 68

References 70

Appendix 78

List of Abbreviations

AEA	American Economic Association
CAPM	Capital Asset Pricing Model
e.g.	“exempli gratia” – for example
et al.	“et alii” – and others
GDP	Gross Domestic Product
i.e.	“id est” – that is
IMF	International Monetary Fund
MFI	Monetary Financial Institutions
MRI	Monetary Financial Institutions Interest Rate
NIPA	National Income and Product Accounts
OECD	Organisation for Economic Co-Operation and Development
OLG	Overlapping Generations
SNA	System of National Accounts
UK	United Kingdom
USA	United States of America
WACC	Weighted Average Cost of Capital

INTRODUCTION

"If a time when we can borrow money in a currency we print ourselves for the long term at 3% and the construction unemployment rate is in double digits is not the moment to repair Kennedy Airport: When will that moment ever, ever be?"

Lawrence Summers (2014)

What Lawrence Summers suggests seems reasonable at a first glance, yet the implication goes against the call for fiscal consolidation that can currently be heard all across the globe. Interest rates in the world's major economies have been low for the past years since the financial crisis in 2008/2009, and benefits can be reaped from this. In Germany, the state is estimated to have saved over €100 billion since 2008 due to lower interest rates.[1] According to the Bundesbank (2013), other governments have also benefitted from this development as a consequence of declining debt services. This eases the pressure on the public budget in these countries and supports fiscal consolidation. In light of the recent sovereign debt crisis in the eurozone, austerity measures have been taken up by most countries to decrease the public debt level. These two effects complement each other and could potentially speed up the process of bringing down public deficits and debt-to-GDP[2]-ratios.

Summers (2013, 2014) looks at this situation from another angle. Instead of letting low interest rates help decrease deficits, he suggests taking advantage of the low price of borrowing money and letting the government spend it, stimulating the economy and inducing growth. Politically, public spending is a lot more desirable than austerity. The public will always prefer voting for a candidate that wants to invest in infrastructure compared to a candidate that wants to raise taxes. However, the desirability of public spending is limited, as the experience in Europe has demonstrated. Too high a level of public debt can lead to sovereign defaults, and recovering from these will most likely put more strain on the public than fiscal consolidation prior to a default. As can be seen in Greece at the moment, recovering from such a crisis comes at high costs.[3] In the meantime, this issue does not only concern Europe.

[1] Handelsblatt (2014).
[2] Gross Domestic Product (GDP).
[3] For an investigation of the effects of fiscal consolidation on household income distribution for nine EU countries, see Avram et al. (2013).

The debt level of the United States of America (USA) is currently at over $17.6 trillion[4], the highest it has ever been. Thinking back to what happened in Europe in the past years, this could be quite alarming. Taking advantage of the low interest rates to bring these numbers down seems like a sensible approach.

It is therefore all the more surprising that several economists such as Lawrence Summers (2013, 2014) or Carl Christian von Weizsäcker (2014) argue in favor of public debt instead. They claim that – for various reasons – many economies are currently growing inefficiently because they have accumulated too much capital. This circumstance can then create a serious threat to prosperity that can only be resolved through public debt.

Summers (2013, 2014) and von Weizsäcker (2014) are not the first economists to suggest that public debt is desirable. If a country has accumulated a lot of capital and as a result grows inefficiently – a state that is also referred to as *overaccumulation* – raising public debt levels is actually a feasible policy. However, if the economy is dynamically efficient, this will only increase the risk of sovereign default due to added pressure on the public finances because the debt has to be served later on. Knowing which state an economy is in is therefore crucial to determining the debt policy a country wants to implement.

This thesis will investigate the circumstances under which public debt does (not) put an additional burden on future generations and assess whether these conditions are fulfilled for the OECD countries plus China. A new criterion that differs from the approaches used so far in the overaccumulation literature will be developed. Applying it to a wide range of different countries will allow for more general results to be obtained, broadening the spectrum of empirical findings.

The thesis is structured as follows: First, an overview of the theoretical background on overaccumulation will be presented and a general criterion will be given to determine whether or not public debt constitutes a "free lunch", meaning that it never has to be paid back. The second chapter will review different empirical evaluations that have already been conducted by other authors and introduce the specific criterion used in this thesis. The analysis is described and results are presented in the third chapter, the discussion follows in the forth chapter. The conclusion sums up the findings and presents opportunities for further research.

[4] Source: http://research.stlouisfed.org/fred2/graph/?id=GFDEBTN, effective September 2014.

Chapter 1: Overaccumulation, Ponzi Games, and an Economy with Land

1.1. What is Overaccumulation?

Overaccumulation is an important topic in the economics literature. Starting in the mid-20th century with articles by Malinvaud (1953), Phelps (1961, 1965), Diamond (1965), Cass (1972) and many more, the concept of overaccumulation and its causes and effects have been investigated more carefully and several theories that are now considered standard literature on the topic were developed.

Put simply, overaccumulation occurs when an economy has accumulated too much capital. As a consequence, it is in a state in which lowering savings by raising consumption would benefit current consumers while not requiring a lower level of consumption later on, leaving future generations unaffected. Spending more money now would therefore not change the amount of possible consumption tomorrow. To demonstrate how this mechanism – which might at a first glance seem odd – works, a look at another standard model in basic macroeconomics can be helpful. Solow (1956) developed a framework for economic growth in which the economy eventually reaches a steady state, which is the case when all factor proportions stay at the same level over time. In its simplest case, a closed economy without government activity and without technological growth is considered. The single-good economy only has two input factors – capital K and labor N – and the output Y is either consumed or invested in the capital stock, which depreciates at rate δ. The production function $Y = F(K, N)$ has standard neoclassical properties in that it has constant returns to scale, exhibits positive marginal products and a diminishing marginal rate of substitution. The wage w is equal to the marginal product with respect to N while the interest rate r is equal to the marginal product with respect to K. Let $k = K / N$ and $\dot{k}$ be k differentiated with respect to time t, keeping N constant. The net capital investment evolves according to

(1) $$\dot{k} = sf(k) - \delta k,$$

where $f(k)$ is the production function per capita and s is the rate of savings of the economy. A steady state is reached when $\dot{k} = 0$. Figure 1 shows how this steady state is determined graphically for two cases.

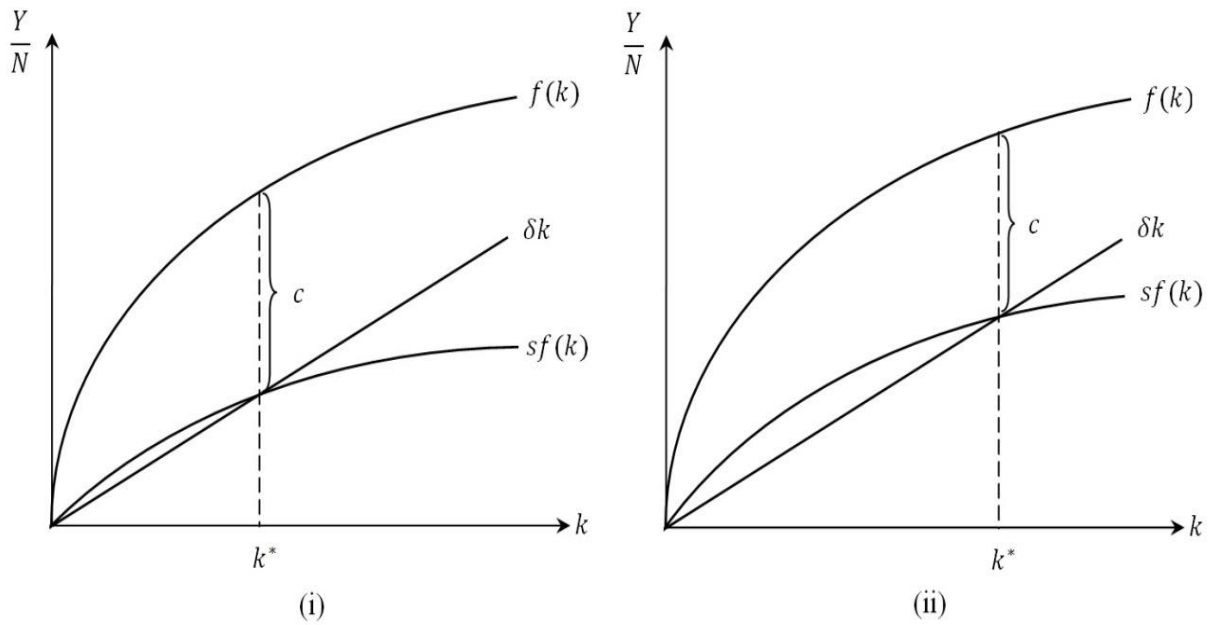


Figure 1 – Steady States in a Solow Model

As shown in Figure 1, it is easy to determine consumption per capita c and thus the amount of savings per capita from the graph. In his "Fable for Growthmen" Phelps (1961) derives a so-called "Golden-Rule of Accumulation" which maximizes consumption in a Solow model and finds that in order to attain the golden rule, the rate of investment, which is equal to the savings rate s, must equal the competitive rate of profits, that is:

(2) $$s_G = \frac{rK^*}{Y^*}$$

The first graph of Figure 1 shows an economy for which equation (2) holds and which is therefore in a state of maximum consumption. The second graph shows an economy with a savings rate higher than the golden rule level. This results in a higher capital stock, a higher output level, and a lower interest rate. On the other hand, per capita consumption c is lower. It is easy to see that by decreasing the savings rate to the level of the left graph, consumption per capita can be increased for the time in which the decrease takes place and also all other periods following the decrease.[5] This is because the economy has accumulated too much capital and can afford to decrease the capital stock. In the opposite case when the savings rate falls short of the golden rule level (the interest rate exceeds the golden rule level), it would need to be increased in order to achieve maximum consumption.

[5] In the model, the transition from one steady state to another takes a long time as the capital stock decreases slowly.

However, this would mean a decrease in consumption until the new capital stock is built up that eventually allows higher consumption, leaving several generations with less to consume compared to their ancestors, as the adjustment to a new steady state does not take place immediately. Solow's (1956) simplified model can be extended to a growing economy with technical advancement without altering this result. A few years after his "Fable", Phelps (1965) revisits the topic and proves that the golden rule path can also be found for un-neoclassical models, using the Harrod-Domar model[6], and investigates the role of technical progress. Relying on a proof by Koopmans (1963), he also shows that a growth path is *dynamically inefficient* when the interest rate is never equal or above the golden rule level, i.e. the capital-output ratio exceeds the golden rule level. Additionally, on the golden rule path that maximizes consumption, the golden rule interest rate is equal to the growth rate g of an economy, given that this maximum is an interior one[7]. Dynamic inefficiency or overaccumulation thus means that due to the fact that $r < g$, there is a way to change the capital stock in such a way that no person is made worse off and at least one generation is made better off, which would then constitute a pareto improvement.

The Solow model is extremely limited in representing real economies, for example it assumes a savings function that is exogenous and does not look at decisions at the household level. A more extensive model that endogenizes the savings rate with a microeconomic foundation was developed by Ramsey (1928) and later extended by Cass (1965) and Koopmans (1963). Looking at household decisions concerning ideal consumption and saving, which depend on the interest rate and utility function, the model derives a savings rate for the economy. This version of the model is a step closer to reality, which might indicate a higher relevance of the model when assessing actual economies compared to the Solow model. Allowing for the savings rate to be determined in a competitive economy yields an interesting result: Dynamic inefficiency is ruled out in the Ramsey model as the savings rate can never exceed the golden rule level. However, this result is due to mathematical assumptions that have to be made about the model, specifically the fact that households live forever and plan accordingly. The resulting budget constraints are only binding if the interest rate never falls short of the growth rate, see von Weizsäcker (1979, pp. 273).

[6] The Harrod-Domar-model is an early post-keynesian economic growth theory developed by Roy F. Harrod (1939) and Evsey Domar (1946). It does not impose the neoclassical assumptions that the production function needs to be twice differentiable, strictly concave, and exhibit positive marginal products at all times. Phelps (1965, pp. 800) thus chooses this model to show that his results do not hinge upon these assumptions being fulfilled.

[7] The other possibility would be a corner maximum at $k = 0$. This option is not of interest in this investigation, as it also implies zero production and zero consumption and is thus trivial.

Therefore, as Romer (2012, p. 63) points out, for this type of economy the first welfare theorem always holds: competitive solutions are pareto-efficient. But before one dismisses dynamic inefficiency as a theoretical issue without relevance for competitive economies because of this finding, a look at another standard model in macroeconomics – the overlapping generations model – is necessary.

1.2. Dynamic Inefficiency in the Diamond Model

The first one to show that dynamic inefficiency is possible in a competitive economy even with perfect foresight was Samuelson (1958). He examined a consumption-loan model and determined interest rates in this economy, assuming an overlapping-generation (OLG) model. In OLG models, individuals live for a limited amount of time only and make their consumption decisions using utility maximization with that bounded horizon in mind. This is a different approach and in direct contrast to the assumption in Ramsey's model where households live forever. Another important difference is that in every period, new agents enter the economy, resulting in infinitely many households. Shell (1971, p. 1002) argues that dynamic inefficiency in the OLG model is due to a "double infinity of traders and dated commodities".

Samuelson's (1958) result was quite surprising, as it showed that even if individuals perfectly know about the future and act completely rational, their decisions are optimal for themselves but can lead to an inefficient growth path when aggregated, see Cass (1972, p. 220) and Scholten (1999, p. 138). Building on his work, Diamond (1965) developed an OLG model that confirms this result for steady state equilibria and examines the effect of national debt on utility in the efficient and the inefficient case. He shows that in the efficient case, national debt causes a decline in the utility of an individual while in the inefficient case it can either lower or raise the utility. He distinguishes between external and internal debt and illustrates that if only internal debt is used, this would raise utility if the economy has accumulated too much capital. This is the basis for the argument that inefficient economies should use government debt to absorb excess capital in order to return to an efficient growth path. However, it also shows that this is a dangerous policy if the economy was believed to be inefficient when it was really not.

OLG models have since become a workhorse model in macroeconomics because they can be used for a wide number of research questions, such as the role of bequest motives[8], the efficiency of public pension schemes[9], or even the optimal number of children[10]. It is also another step closer to modeling reality compared to the assumption that individuals live forever. Due to its high significance and versatility, the Diamond model will now be examined closer to show how overaccumulation can occur in an OLG model.

In Diamond's model individuals live for two periods. The population grows at rate n, so that $N_{t+1} = (1+n)N_t$. When they are young, individuals work and earn a wage, which is the marginal product of the production function $F_t(K_t) = F(N_{t+1}, K_t)$ with respect to labor N_{t+1}. When they are old they don't work anymore but still consume. They use their income from the first period to finance consumption and save for retirement, which they do through purchasing bonds from firms. The firms issue the bonds to pay for investments and in the following period redeem the bonds, paying an interest factor R_{t+1} which is equal to the marginal productivity of capital in equilibrium. They also pay wage rates in that period. Output Y_t is thus produced using the young generation for labor and the capital stock K_t, which is held by the old generation. The profit of the firms equals

(3) $$F(N_{t+1}, K_t) - w_{t+1}N_{t+1} - R_{t+1}K_t.$$

The budget constraints of the households are

(4) $$C_t^1 + S_t = w_t$$

(5) $$C_{t+1}^2 = R_{t+1}S_t$$

where C_t^1 is consumption when young, C_{t+1}^2 consumption when old, S_t the amount of bonds purchased and w_t the wage received. A steady state is reached when all factor proportions remain constant. In this competitively determined equilibrium $S_t = K_t$.

[8] See for example Barro (1974), Weil (1987), Abel (1987).
[9] See for example Aaron (1966), Breyer (1989).
[10] See for example Raut (1990).

Now let U_t be an individual's utility in period t given by

(6) $$U_t = \beta \frac{C_t^{1\,1-\theta}}{1-\theta} + \frac{C_{t+1}^{2\;\;1-\theta}}{1-\theta}, \qquad \theta > 0; \theta \neq 1$$

where θ determines the elasticity of marginal utility. The higher θ, the higher the individual's wish to smooth the consumption path. β reflects the pure rate of time preference. Substituting (5) into (4) yields the budget constraint

(7) $$C_t^1 + \frac{C_{t+1}^2}{R_{t+1}} = w_t$$

In order to determine the optimal consumption path, U_t needs to be maximized with respect to C_t^1 and C_{t+1}^2. This can be done using the standard LaGrange method.

(8) $$L = \beta \frac{C_t^{1\,1-\theta}}{1-\theta} + \frac{C_{t+1}^{2\;\;1-\theta}}{1-\theta} + \lambda\left(w_t - C_t^1 - \frac{C_{t+1}^2}{R_{t+1}} \right)$$

Differentiating with respect to C_t^1 and C_{t+1}^2, and solving for C_{t+1}^2 yields

(9) $$C_{t+1}^2 = \left(\frac{R_{t+1}}{\beta} \right)^{1/\theta} C_t^1$$

Substituting this into the budget constraint (7) and solving for C_t^1, one obtains

(10) $$C_t^1 = \frac{\beta^{1/\theta}}{\beta^{1/\theta} + R_{t+1}^{(1-\theta)/\theta}} w_t,$$

which, combined with (4) shows that

(11) $$S_t = \left(\frac{R_{t+1}^{(1-\theta)/\theta}}{\beta^{1/\theta} + R_{t+1}^{(1-\theta)/\theta}} \right) w_t.$$

The number of bonds bought by the households thus does not depend solely on the wage, but also the interest factor and the time preference. And what is more, the effect of the interest factor depends on θ. For $\theta < 1$ the number of bonds bought will increase with a rising interest rate. For $\theta > 1$ it will decrease, while for $\theta = 1$, which is the case for logarithmic utility functions, the interest factor has no effect on the amount of saving at the household level.

With the wage rate and the interest factor both being equal to the marginal productivity of labor and capital respectively, the equation of motion for the capital stock crucially depends on the production function. Without further specification, it is not possible to find a general solution for the evolution of the capital stock. Therefore, an example following Homburg (2014) will now be used to illustrate the mechanisms in the Diamond model.

Let $U_t = \beta \ln C_t^1 + C_{t+1}^2$ and $F_t(K_t) = 9K_t^{1/3}N_t^{2/3}$. Labor is constant and normalized to unity. C_t^1 and S_t have already been determined for the general case. Plugging in $\theta = 1$ because of the logarithmic utility function yields

(12) $$C_t^1 = \frac{\beta w_t}{1+\beta} \qquad S_t = \frac{w_t}{1+\beta}$$

Using (5), C_{t+1}^2 is easily determined to be

(13) $$C_{t+1}^2 = \frac{w_t R_{t+1}}{1+\beta}.$$

Firms maximize their profit π that is given as

(14) $$\pi = 9K_t^{1/3}N_{t+1}^{2/3} - w_{t+1}N_{t+1} - R_{t+1}K_t$$

Maximizing with respect to K_t and N_{t+1} yields

(15) $$w_{t+1} = 6K_t^{1/3}N_{t+1}^{-1/3} = 6K_t^{1/3}, \qquad \text{with} \quad N_{t+1} = 1,$$

(16) $$R_{t+1} = 3K_t^{-2/3}N_{t+1}^{2/3} = 3K_t^{-2/3}, \qquad \text{with} \quad N_{t+1} = 1.$$

As the utility function is logarithmic, the interest factor has no effect on the amount of bonds purchased, as can be seen from (12). However, the wage rate, determined through the capital stock from the previous period as shown in (15), sets the amount of saving and thus the next capital stock because $S_{t+1} = K_{t+1}$. Combining (12) and (15) one obtains

(17) $$K_{t+1} = \frac{6K_t^{1/3}}{1+\beta}.$$

A stationary state is established when the capital stock remains unchanged, so solving for $K_{t+1} = K_t = K$ and substituting the result into (16) yields

$$K = \left(\frac{6}{1+\beta}\right)^{3/2} \quad \text{and} \quad R = \frac{1+\beta}{2} \tag{18}$$

as the equilibrium capital stock and equilibrium interest factor.

Due to the fact that this is a stationary state, the growth factor of the economy is $G = 1$. The golden rule interest factor that maximizes consumption is therefore also equal to 1 and emerges when $\beta = 1$. For any $\beta < 1$ the economy will reach an inefficient stationary state because the interest factor will be smaller than the growth factor. A $\beta > 1$, implying a higher preference for present consumption, will keep the economy in an efficient state since the individuals will not save more than they would at the golden rule level. Table 1 provides numeric examples for the three cases.

	$\beta = 0.75$	$\beta = 1$	$\beta = 1.25$
K	6.35	5.2	4.35
Y	16.66	15.59	14.7
C	10.32	10.39	10.34
R	0.88	1	1.25

Table 1 – Capital Stock, Output, Consumption, and Interest Rate in the Diamond Model

Own calculation based on the example in the text. Values are rounded to two decimal points.

As can be seen from these examples, a state of overaccumulation can occur if the time preference is such that consumption of goods in the future is valued higher than consumption today. This result is quite intuitive. If individuals receive a higher utility from consumption in the future, like in the case of $\beta = 0.75$, they will save more and the resulting higher capital stock will depress R, as can be seen from (18). Without any limitations on the value of β, overaccumulation cannot be ruled out. Setting boundaries for β would only decrease the scope of the model and there is no reasonable justification to do so. Thus, the standard Diamond model is prone to dynamic inefficiency.

1.3. Assessing Dynamic Efficiency

Determining whether or not an economy is in a dynamically inefficient state is of great interest for policy implications because it has drastic implications on the effect of these policies. Inspired by Phelps' (1965) article on dynamic inefficiency, Cass (1972) explores the possibility of finding an observable characteristic of an economy that accumulates too much capital.

His reasoning is as follows: If the economy is inefficient, one could simply decrease the capital stock and as a result consumption could be increased for the current period without diminishing it in the future. If no such reduction can be undertaken without bringing down consumption in the future, a growth path is called dynamically efficient. Another way to put this is that an inefficient economy can achieve the same consumption path starting from a lower capital stock. He compares the "excess" capital over the efficient lower level of capital to a useless Swiss bank account where money is never taken out. Clearly, such a state is not desirable. Analyzing the effect of capital stock reductions over time, he derives the requirements under which such reductions are feasible and thus a criterion for dynamic inefficiency. The focus of this criterion lies on the eventual behavior of the net interest rate of the economy. A necessary condition for inefficiency is that the future value of a unit of capital in period 0 becomes zero in the limit, due to increasingly unfavorable terms of trade. A sufficient and necessary criterion is that this deterioration in the terms of trade happens at a rapid rate. If this does not happen, the economy is efficient. Put differently in terms of interest and growth factors R and G [11], the economy is efficient if the product $R_2 / G_2 \ldots R_T / G_T$ diverges, see Homburg (2014, p. 19).

Cass' (1972) proof has been reproduced by many authors when extending the search for (in)efficiency criteria under different circumstances. While Cass (1972) described an economy under certainty, Zilcha (1990, 1991) examined stochastic models that allow for uncertainty. In his first paper, he focuses on a growing economy, whereas in his second paper he derives necessary and sufficient conditions for inefficiency in a stationary model. While his criterion reads slightly differently than the Cass (1972) criterion, the essence is the same. However, as was later pointed out by Rangazas and Russell (2005) and Barbie and Kaul (2009), there are several errors in Zilcha's (1990, 1991) proofs with respect to the necessity and sufficiency of his criterion.

[11] Where Phelps uses interest and growth *rates,* Homburg (2014) uses interest and growth *factors*. Interest/growth factors and interest/growth rates are related as follows: R = (1+r) and G = (1+g).

The main result of these two papers is that Zilcha's (1991) criterion for stationary economies is not a sufficient criterion for inefficiency. Nonetheless, the criterion is sufficient to assess dynamic efficiency. This is important because it means that the Cass (1972) criterion for efficiency as a diverging series of the product $R_2 / G_2 \ldots R_T / G_T$ is also valid in a stochastic stationary economy. Another extension confirming the Cass (1972) criterion was published by Balasko and Shell (1980) and deals with exchange economies.

Also following the Cass (1972) line of argument, Homburg (2014) develops a criterion to assess dynamic efficiency that is quite general as it does not impose the otherwise often needed Inada[12] or boundedness assumptions. The model allows for population growth as well as technical change and linear production functions. His derivation will now be presented.

Homburg (2014) examines a model with a homogenous output $Y_t > 0$ that can either be used for consumption $C_t \geq 0$ or capital formation $K_t \geq 0$, where t denotes the period. He disregards market institutions, and capital depreciates fully. The capital stock and output have the following relationship:

(19) $$Y_{t+1} = F_t(K_t) = C_{t+1} + K_{t+1} \qquad \text{for} \quad t = 0,1,2,...$$

The marginal productivity of capital $dF_t(K_t) / dK_t = R_{t+1}$, referred to as the interest factor, is strictly positive and the production functions $F_t(K_t)$ are time dependent. The growth factors G_t of the economy are defined as $G_t = Y_t / Y_{t-1}$ and the output in period T thus becomes

(20) $$Y_T = Y_1 G_T \ldots G_3 G_2.$$

Suppose the economy is in a state of inefficiency. Then there exists a positive capital stock reduction $\varepsilon_t > 0$ that leads to an increase in consumption in period t without negatively affecting future consumption. If in $t = 1$ on reduces K_1 by $\varepsilon_1 > 0$ this leads to an increase in C_1 by ε_1. As a result, the output in $t = 2$ will fall by at least $R_2 \varepsilon_1$ to a lower level compared to the path without the reduction. However, the consumption need not be affected if the inefficient case truly holds. In order to keep C_2 at the same level, K_2 must be decreased by $\varepsilon_2 \geq R_2 \varepsilon_1$. In $t = 3$, Y_3 falls by at least $R_3 R_2 \varepsilon_1$ and K_3 must be reduced by $\varepsilon_3 \geq R_3 R_2 \varepsilon_1$ if C_3 is to remain the same.

[12] The Inada conditions go back to Kenichi Inada (1964) and state that $\lim_{k \to 0} f'(k) = \infty$ and $\lim_{k \to \infty} f'(k) = 0$, ensuring that the economy does not diverge (see Romer, 2012, p. 12).

The same logic applies to all periods after that, showing that the reduction in the capital stock at time T is equal to $\varepsilon_T \geq R_T \ldots R_3 R_2 \varepsilon_1$. The upper limit for the reduction is the produced output in period T so $\varepsilon_T \leq Y_1 G_T \ldots G_3 G_2$. This leads to $R_T \ldots R_3 R_2 \varepsilon_1 \leq \varepsilon_T \leq Y_1 G_T \ldots G_3 G_2$ and therefore

$$\varepsilon_1 \leq Y_1 \frac{G_2 G_3 ... G_T}{R_2 R_3 ... R_T} \qquad \text{for} \quad T = 2, 3, \ldots \tag{21}$$

If the reduction is feasible and $\varepsilon_1 > 0$, the economy is dynamically inefficient. This condition is not fulfilled if the compound interest factor $\prod_{t=2}^{T} R_t$ exceeds the compound growth factor $\prod_{t=2}^{T} G_t$, which would lead the fraction on the right-hand side to approach zero in the limit, making $\varepsilon_1 \leq 0$. Therefore, if

$$\frac{G_2 G_3 ... G_T}{R_2 R_3 ... R_T} \to 0 \qquad \text{for} \quad T \to \infty \tag{22}$$

the economy is dynamically efficient. No feasible reduction in K is possible.

In a steady state with fixed factor proportions and constant growth rates, this implies that $R > G$ for the economy to be efficient, showing the connection to Phelps' (1965) results. This reduces the assessment of dynamic efficiency to a comparison of interest and growth rates.

However, as can be seen from (22), one needs to look whether or not R exceeds G in the limit when evaluating the efficiency of an economy. Only the eventual behavior of these variables matters. This means that the interest factor can fall short of the growth factor at times and that this can even be a state lasting for a long time, which might lead the observer to conclude that the economy grows inefficiently. But as long as the economy turns back to the case of $R > G$ in the long run, dynamic efficiency is ensured. As it is impossible to determine the future path of economic indicators with certainty, this poses a problem concerning the reliability of the results from an empirical comparison. Nonetheless, empirical tests can still yield credible results if one assumes that the relationship between R and G is a stochastic process that is ergodic.[13] If it is, this would imply that the behavior of these variables observed in a sample on average converges to the behavior that can on average be observed over the entire horizon. Thus, if in a sample the average interest rate exceeds the average growth rate, the assumption of ergodicity leads to the conclusion that (22) holds, meaning that the economy is efficient.

[13] For more on ergodicity, see Billingsley (1995).

Ergodicity is therefore a useful concept when empirical tests for dynamic efficiency are conducted. Homburg (2014, p. 16) and Barbie et al. (2004, p. 10) also explicitly make use of this condition.

The past two sections introduced the Diamond model, showed how dynamic inefficiency can occur in an overlapping generations model and that an economy is dynamically efficient if $R > G$ in the limit. The next section focuses on the consequences of dynamic inefficiency.

1.4. Ponzi Games

As has already been described, a state in which the economy has accumulated too much capital is not desirable to maintain, because the economy foregoes the potential of a higher consumption that could be achieved at no cost. In addition, dynamic inefficiency enables asset bubbles, as was shown by Tirole (1985), and Ponzi schemes become feasible, which is basically equivalent, as O'Connell and Zeldes (1988) argue.

A Ponzi scheme is characterized by the issuance of debt and then rolling it over forever, never having to serve it.[14] As Romer (2012, pp. 588) explains, a Ponzi scheme in the Diamond model is feasible if the interest rate falls short of the growth rate. In this case, the government could raise a certain amount of debt at time 0 and issue new debt to pay for the interest and the principal of the original debt. The next time the debt is due, new debt will once again be issued to pay the principal and interest. That way, the value of the debt grows at the current interest rate. If this rate is below the growth rate, this implies that the output of the economy grows faster than the debt and the debt-to-GDP-ratio converges to zero. By playing such a Ponzi game, the government can reduce the capital stock and attain the golden rule level, thus eliminating the inefficiency. To do so they have to get the households to hold government debt instead of bonds by firms, reducing the investment in the capital stock. Due to the fact that the initial debt never has to be paid back, the possibility of a Ponzi scheme is often referred to as a "free lunch". However, if the economy is dynamically efficient and the interest rate is above the growth rate, the debt grows faster than the output of the economy and has to be served sooner or later.

[14] The concept goes back to Carlos Ponzi, after whom the scheme was named. In the 1920s, Ponzi owned a small loans company in Boston and received loans from customers promising to pay 30% in interest each month. He financed this interest by collecting more loans. The system collapsed when the income from new deposits fell short of the interest he had to pay (Kindleberger and Aliber, 2005, p. 28). A similar scheme that attracted much attention in more recent times was the Ponzi game by Bernard Madoff. For more on the Madoff fraud, see Stowoly et al. (2014).

This result is important for policy implications. If an economy is dynamically inefficient, raising government debt is not only feasible but would also help the economy escape the inefficient state. Large budget deficits would then be beneficial to the economy as a whole. If the economy is dynamically efficient, such a Ponzi scheme cannot be successful and any debt raised will shift the burden of serving it into the future.

The next section will introduce an extension to the Diamond model that introduces land into the economy with drastic implication for the dynamic behavior.

1.5. A Modified Diamond Model – The Introduction of Land

This section introduces a revised version of the Diamond model proposed by Homburg (1991, 1992, 2014) that adds land as a production factor and shows that this renders dynamic inefficiency impossible. Thus, if land plays an important role in an economy, ignoring it could lead to wrong conclusions concerning policy implications.

Going back in the economics literature, land used to be a standard ingredient for economic models before the 20th century, making up part of the classical factors of production – land, labor, and capital.[15] Ricardo (1817), and Turgot (1770) are just a few authors who included land in their considerations. Nowadays, models that incorporate land are seldom developed in the field of economic growth. Homburg (1991) blames this development on the focus on steady state analyses within growth theories. As mentioned before, a steady state is defined as a state in which the factor proportions stay constant. In a model with land and population growth, the land/labor ratio as opposed to the capital/labor ratio will vary over time due to the fact that land is fixed in quantity whereas labor grows. This also means that the rent/wage ratio will differ, and the basis for deriving steady states no longer exists. It is therefore necessary to look at arbitrary growth paths instead of steady states. This approach is mathematically more challenging and according to Homburg (1991, 2014) the main reason for abandoning land as a production factor in neoclassical models.

[15] "The categories are characterized by a purely economic trait: they are respectively the suppliers of services of land, of labor, and of a stock of goods that is labeled 'capital'. This seems to settle their role in production and, quite unbidden, the famous triad presents itself, the triad of agents, or factors, or requisites – or instruments (Senior) – of production" (Schumpeter, 1954, p. 531). In the past decades, this concept has been complemented by other factors. For a review and discussion on this issue, see Dean and Kretschmer (2007).

There are important insights to be gained from an analysis that includes land, as will be shown in this section. The central result was first discussed by Turgot (1770: 82ff.) and states that the interest rate in a stationary economy must be strictly positive due to a simple arbitrage calculation. A person can choose to invest capital in different ways, including a purchase of land that produces a revenue each year that shall be called the rent ρ, or lending it to other people at an interest rate r. Then, people have the choice to buy a certain amount of land at a price q, collect the revenue and then sell the land at the exact same price one period later, or to lend the money for one period and earn an interest rate. If it is assumed that they have no preference for either form of investing the money, the following equation must hold in equilibrium:

$$1 + r = \frac{q + \rho}{q}. \tag{23}$$

Otherwise, arbitrage becomes possible. For example, if interest rates are lower, people would borrow money and invest it in land purchases, making more money from the land revenue than they have to pay back in interest. That way, they would be able to make money out of thin air, and this can clearly not be an equilibrium solution. The interest rate will have to adjust in accordance to (23) to make arbitrage impossible, based on the assumption that the investor is indifferent between the two options. Turgot (1770: 82) goes even further and states that a loan is much riskier than investing in land, owing to the threat that the debtor won't be able to pay back the loan and default becomes necessary. Due to the risk associated with lending money, the interest rate r must thus in fact *exceed* the return on land. Looking at (23) makes it clear: If the price of land and the revenue are strictly positive, which is in no way an unreasonable assumption to make, the interest rate must also be strictly positive. Additionally, it shows the direct relationship between r and q. If a large number of land owners decide to sell their land, driving down its price, the interest rate must increase in order to keep lending money a feasible alternative to buying land. Or put differently: If the interest rate decreases and thus lending becomes less profitable, the price of land will increase to preserve sufficient investment options. This way, if the interest rate in a stationary state approaches zero – the golden rule level – land prices will be infinitely high, keeping the interest rate from ever falling below the growth rate. This mechanism provided by an alternative investment opportunity obtainable at all times keeps the economy from saving too much money, and thus accumulating too much capital.

Homburg (1992, 2014) extends this idea to an arbitrary growth path and confirms that, when land is taken into account, overaccumulation is rendered impossible. In his analysis, factor proportions are not fixed and price fluctuations are accounted for. In the earlier version of his theory, he shows that this result also applies under assumptions that allow for a high degree of heterogeneity when it comes to land qualities, household and firm preferences as well as technical progress. However, as this proof is quite involved and yields no additional insights relevant for the scope of this thesis, the following verification will be taken from his recent article, keeping in mind that compared to other growth models, the results do not rely on many assumptions.

Building on the example explained in the previous section, a model with land is derived. Firms now also buy land L that they need to produce their output and issue bonds to finance their investment. Land and Output are sold one period later and the bonds are redeemed. The profit π is now derived as follows

(24) $\pi = F(N_{t+1}, K_t, L) + q_{t+1}L - w_{t+1}N_{t+1} - R_{t+1}(K_t + q_t L)$ for $t = 0,1,2,\ldots$

In accordance with the wage and the interest rate, the rent of land ρ_{t+1} is equal to the marginal productivity of land

(25) $$\rho_{t+1} = R_{t+1}q_t - q_{t+1} \qquad \text{for } t = 0,1,2,\ldots$$

and, solved to parallel (23),

(26) $$R_{t+1} = \frac{q_{t+1} + \rho_{t+1}}{q_t} \qquad \text{for } t = 0,1,2,\ldots$$

It can also be seen easily that $q_t = (q_{+1} + \rho_t) / R_{t+1}$. Calculating the present value of a piece of land sold in period T yields

(27) $$q_1 = \frac{q_T}{R_2 R_3 \ldots R_T} + \sum_{t=2}^{T} \frac{\rho_t}{R_2 R_3 \ldots R_T} \qquad \text{for } t = 0,1,2,\ldots$$

The first term equals the present value of the price at which the land is eventually sold, and the second term amounts to the present value of all future land rents up to period $T \geq 2$. It is assumed that there is a strictly positive land income share $\rho_t L / Y_t$ that satisfies $\rho_t L / Y_t \geq \lambda > 0$.

Rearranging this yields

(28) $$\rho_t \geq \frac{Y_t \lambda}{L}, \qquad t \geq 2.$$

After inserting (20) into the above equation, plugging it into (27) and dropping the first term of that equation, one obtains a lower estimate of q_1:

(29) $$q_1 \geq \sum_{t=2}^{T} \frac{Y_1 G_2 G_3 ... G_t \lambda L}{R_2 R_3 ... R_t}.$$

Rearranging to solve for the land share in total output and setting $T = \infty$ shows

(30) $$\frac{q_1 L}{Y_1} \geq \lambda \sum_{t=2}^{\infty} \frac{G_2 G_3 ... G_t}{R_2 R_3 ... R_t}.$$

As the total land share cannot exceed output, the right-hand side of the equation must be less than or equal to one. Thus, the sum cannot reach infinite values, implying that its elements must converge to zero. This is in accordance with the efficiency condition derived in (22). A proof paralleling the stationary state example given earlier but including land can also be found in Homburg (2014), showing that even as the time preference rate β approaches zero, rising land values will keep the interest factor R above one. This is due to the fact that introducing land into the model enables households to trade in an additional market, serving as an alternative savings vehicle. The result is a market mechanism that automatically prevents the interest rate from falling below the growth rate in the limit.

Homburg (2014, pp. 10) then goes on to show that land is empirically relevant, pointing out that land values exceed GDP and public debt in all of the countries he considers, and even coming close to the value of reproducible capital in most countries. Hence, it would be a capital mistake to ignore land in the assessment of an economy. For the evaluation of dynamic efficiency, this has strong implications, because it means that overaccumulation is an issue of purely theoretical nature and never a state that could actually be realized. This also rules out the possibility of Ponzi schemes and with that the feasibility of public debt.

There are of course objections to Homburg's (1991, 1992, 2014) theory. Homburg (1992, p. 51) himself mentions that his theory could fail in the absence of perfect competition. On the other hand, this is a standard assumption in economic models and dropping it would invalidate several theories commonly drawn upon. Hence, it is not a flaw inherent to Homburg's theory but rather a limitation most theories are subjected to.

Von Weizsäcker (2014, pp. 48) argues that land values will not go beyond any limit to offset the fall in interest rates due to insecure property rights. He mentions expropriation and taxation as of the main sources that are especially effective because land, as opposed to other possessions, cannot be moved abroad. Therefore, the price of land includes a risk premium that keeps it from reaching infinitely high values. Kim and Lee (1997) also argue that taxation could still lead to inefficiency in an economy with land. Homburg (2014, 2014:2) evaluates these claims and proves that these allegations are incorrect, as long as the land rent is not completely taxed away. A tax that affects capital and land to the same degree will not change the arbitrage condition (26). Even a tax on rent or land values leaves the results unchanged, as long as the after-tax rent is still positive. Additionally, as can be seen in Homburg (1992, pp. 40), the term "land" is representative for all commodities that don't need to be produced, cannot be reproduced, and are not used up. For example, the criteria also apply to works of art[16], which are not subject to the immobility of actual land.

As for expropriation, Homburg (2014) also points out that historically, the risk of expropriation rose with increased government spending. This implies that motivating further debt with the invalidity of the land theorem due to expropriation risks constitutes a self-fulfilling prophecy. Additionally, the recent experience in Greece shows that government bonds are just as prone – if not more – to expropriation, preserving the validity of the land theorem.

[16] Homburg (1992, p. 42) gives the example of a picture by Rembrandt.

Chapter 2: Applying the Theory – Methods of Assessing Dynamic Efficiency

In order to derive policy implications from the theories described in the last chapter, a closer look at real economies is necessary. Many authors have tried assessing dynamic (in)efficiency for different countries. This chapter will examine four empirical studies conducted in the past decades that used different measures to evaluate the state of several economies. It will then be shown that some of these approaches are not appropriate due to needing strong assumptions and yielding contradictory results. This applies to the measures that do not rely on a comparison of interest and growth rates as presented in Chapter 1.3.. However, if the interest and growth rate comparison is chosen to assess dynamic (in)efficiency, the decision which interest rate to use is crucial for the results of the analysis. Therefore, different interest rates that have been used in past analyses or that have been mentioned in public discussions on the topic will be considered. It will become clear that none of these seem to suffice for an accurate assessment of overaccumulation. Therefore, a new interest rate that has not yet been considered in this context will be presented.

2.1. Review of Important Empirical Studies So Far

Abel et al. (1989) published a paper that has been very influential on the topic of assessing dynamic efficiency up to this day. Prior to their publication, an approach based on the theoretical work by Phelps (1961), Diamond (1965) and others as described in the first chapter has been used to judge dynamic efficiency for economies. However, instead of looking at growth and interest rates and how they relate to each other, they develop a new criterion. Arguing that the marginal productivity of capital is not observable, they propose a test based on the relationship between investment and return on capital which can be calculated using observable figures. This criterion is derived from a generalization of the Diamond (1965) model that accounts for stochastic population growth and production technology, while the production technology is kept very general and considers changes in the relative prices. Abel et al. (1989) define a net dividend that is equal to profit less investment of the market portfolio. If that dividend divided by the ex-dividend value of said portfolio is positive at all times in all states of nature, then the economy is dynamically efficient.

Conversely, if the fraction is negative at all times in all states of nature, the economy is inefficient, a proposition that they prove following the line of argument Cass (1972) used. The criterion thus requires strong assumptions to yield a definitive result.

Abel et al. (1989) also extend their criterion to an alternative measurement through interest and growth rates to relate it to the standard concept. They argue that the safe interest rate on government bonds is not suitable to evaluate dynamic efficiency when compared with the growth rate. Instead, they propose to use the rate of return on the market portfolio and compare it to the growth rate of the market portfolio. In that case the economy can be said to be dynamically efficient if the interest rate always exceeds the growth rate and inefficient if it always falls short. Alternatively, one could indeed use the easily-determined safe interest rate, but then it is necessary to compare it to the growth rate of the market value of the capital stock, which strongly fluctuates due to capital gains and losses and would as a criterion most likely remain inconclusive. This way of assessing dynamic efficiency is therefore not practical for assessing actual economies, which is why they use the net dividend criterion in their assessment.

They derive the measure for gross capital income – the profit – by taking the national income, adding capital consumption allowances and then subtracting employee compensation and an estimate of the labor income of proprietors.

They are thus left with a residual that measures profit, rental, and interest income. Gross investment corresponds to residential and nonresidential capital and includes increases in inventories. Subtracting investment from profit then yields the dividend, which has to be divided by the market value of outstanding equity plus net financial liabilities. They use data from the National Balance Sheets and the National Income and Product Accounts (NIPA) for the USA and OECD data for the other countries they evaluate.

Using this criterion, they assess dynamic efficiency for the USA (1953-1985), England, France, Germany, Italy, Canada, and Japan (1960-1984) and find that all these countries fulfill the criterion during the time observed. However, they note like Phelps (1961) that no certain assessment is achievable unless one takes the whole growth path of an economy into consideration, which would include all future paths as well as the past. Since it is not possible to know whether the dividend criterion will be satisfied in the future, their result only implies dynamic efficiency if it is assumed that the economies have always behaved the way they did during the observed period and will continue to behave that way forever.

Geerolf (2013) revisits the theory of Abel et al. (1989) and, using updated data and more countries, reevaluates their results. He extends the analysis to include Australia, Belgium, Denmark, Hungary, Norway, Russia, South Korea, Sweden, and Switzerland. He uses updated data on National Accounts provided by the OECD, which also includes mixed income that the NIPA neglect. In addition, he also uses country specific land data taken from the OECD database and Goldsmith (1985) to subtract land income from the dividend. Abel et al. (1989) falsely include land in their estimate due to a lack of reliable data, but state that adjusting their estimates for a rental income on land of up to 10% would not overturn their results. Geerolf (2013), having this data at his disposal, is thus able to establish an updated version of the dividend criterion. Evaluating the different countries, he finds that – contrary to Abel et al.'s (1989) assessment – none of the countries under consideration can be declared to work efficiently. He even finds evidence that suggests that Japan and South Korea are overaccumulating capital.

Barbie et al. (2004) also review the paper published by Abel et al. (1989) and critically evaluate the net dividend criterion. They argue that the criterion developed by Abel et al. (1989) is in fact a criterion to determine interim pareto optimality.[17] This does not conflict with the results and implications of Abel et al. (1989) per se – if an economy is pareto optimal, it is also dynamically efficient. Conversely, a dynamically efficient economy can still be pareto suboptimal[18]. As a result, assessing pareto optimality requires far stronger assumptions than assessing dynamic efficiency, and applying a criterion meant for the former to evaluate the latter can lead to wrong conclusions. They develop a criterion based on Zilcha (1991) that goes back to the idea of comparing growth rates and interest rates and indicates dynamic efficiency if on average the interest rate exceeds the growth rate. This criterion is then applied to the USA using data from 1890-1999. The interest rate corresponds to the capital rental rate derived by Mulligan (2002)[19], which is calculated dividing capital income by capital. The growth rate is calculated using data obtained from Romer (1989) for 1890-1928 and from NIPA for 1929-1999.

[17] Abel et al. (1989, p. 15) also indicate in their paper that their "criterion is the dynamic analogue of the standard Pareto criterion", though as Barbie et al. (2004) point out, this has been overlooked by some of the literature.

[18] Under certainty, the two concepts of dynamic efficiency and pareto optimality coincide. Allowing for uncertainty opens up a new source of inefficiency in OLG models that stems from incomplete risk-sharing. In this case, *sophisticated Ponzi schemes* can be feasible if the interest rate on government debt is below the growth rate even though the economy is not overaccumulating capital. For more on this, see Barbie et al. (2001, 2004), Blanchard and Weil (2001), or Ball et al. (1998). For the remainder of the thesis, the focus will be on the classical Ponzi schemes that are ruled out by dynamic efficiency in the sense that the economy can lower savings now without having to depress future consumption. Rejecting the feasibility of sophisticated Ponzi schemes requires more assumptions that lie beyond the scope of this thesis. Additionally, if land is introduced into the model, inefficiency due to incomplete risk-sharing is rendered impossible, as Richter (1993) has shown.

[19] More on this later under Chapter 2.2..

They find that the US economy is dynamically efficient, but that the interest rate did fall short of the growth rate at times. They point out how this would conflict with the net dividend criterion by Abel et al. (1989). Using the interest rate extension by Abel et al. (1989) to their criterion, Barbie et al.'s (2004) results would remain inconclusive with respect to the assessment of dynamic efficiency, since it would need the interest rate to either always exceed the growth rate (for efficiency) or always fall short (for inefficiency). Therefore, Abel et al. (1989) would not indicate dynamic efficiency with these interest rates, whereas the criterion by Barbie et al. (2004) clearly does. The difference is that Barbie et al. (2004) only assess dynamic efficiency, not pareto optimality. Since the criterion by Abel et al. (1989) indicated interim pareto optimality, but using interest rates according to their approach would remain inconclusive, something is clearly at odds with respect to the results.

Yet another very recent assessment is presented by Homburg (2014). After evaluating the possibility of overaccumulation in the presence of land (see Chapter 1.5.), he turns to evaluating dynamic efficiency for the US economy and the eurozone. Just like Barbie et al. (2004), he makes use of the comparison of interest and growth rates. The derivation of his criterion has already been presented in Chapter 1.3..

His approach suggests that the relevant interest rate for the assessment of dynamic efficiency has to reflect the uncertainty faced by firms when choosing their investment strategy. As firms use a mix of debt and equity for financing investment – and equity financing is generally assumed to yield a higher return – the cost of debt financing corresponds to a lower estimate of the cost of capital actually faced by firms. Therefore, if this rate can already be shown to ensure dynamic efficiency, then so will other measures reflecting the cost of capital more closely. Homburg (2014) uses Moody's Aaa bond yields for the US (1985–2013) and interest rate data provided by the ECB for the eurozone (2003–2013) and compares them to the growth rate of the economies. His results show that while in both cases the interest rate is not above the growth rate at all times, it is still greater on average by a visible margin and thus indicates dynamic efficiency. He also mentions considering Japan and other countries without finding evidence of dynamic inefficiency anywhere, though he does not present these results.

Some of the results by these authors seem to contradict each other, which poses the question of the reliability of these different measures. This becomes especially clear in the case of the net dividend criterion developed by Abel et al. (1989), which was not only shown to yield different conclusions when using more appropriate data but also argued to be unsuitable to test for dynamic efficiency due to necessarily strong assumptions.

The causes of these claims will now be examined closer to see whether the net dividend criterion could still be used to reliably determine the efficiency of an economy.

The assessment conducted by Abel et al. (1989) is biased in several aspects, which was one of the main reasons for Geerolf (2013) to update their data. First, as previously stated, they include land in their criterion, which as a non-reproducible asset is not capital in the sense that the dynamic efficiency theory is concerned with. Rental income should therefore not be included in the analysis.[20] Abel et al. (1989) acknowledge this shortcoming, but due to a lack of specific data on land they include it, leading their criterion to be possibly overoptimistic of efficiency. Nevertheless, they state that accounting for a rental income share of 5%, an estimate originally proposed by Rhee (1988), their results do not change and remain the same even if a higher rental rate (up to 10%) is assumed. Another potential falsification of the data is possible if the assumptions of perfect competition and constant returns are violated, leading to an inclusion of e.g. monopoly rents in the investment returns and thus again pushing up the dividend.

Abel et al. (1989) are also aware of this complication, even so they believe this effect to not be significant and refer to the observation that Tobin's q for the USA equals one on average over the past five decades.[21] A further weak point in the calculation is the estimate of the labor income of proprietors. As Geerolf (2013) states, the NIPA only account for mixed income of proprietors, but not of unincorporated enterprises, and therefore exclude a portion of mixed income earned in the economy. Furthermore, there is the question of how much of the mixed income should be attributed to capital and how much to labor. Abel et al. (1989) impute 1/3 of mixed income to capital, which corresponds to the value traditionally used.[22] Still, choosing a slightly different value can have drastic effects on the outcome.

Calculating the profit as a residual size from National Accounts is at the heart of these problems. It leads the dividend to include not only estimates for monopoly rents and land rents, but also services of owner-occupied housing, as Homburg (2014, p. 16) points out. These items are important for measuring the GDP and are therefore included in those numbers. However, they are not capital as is understood in the context of dynamic efficiency. They would hence have to be disentangled from the GDP, and even then it is not clear whether all that remains is truly only *capital*.

[20] This also applies to income from other non-reproducible assets such as natural resources (Geerolf, 2013). However, determining their value is equally or in some cases even more difficult.

[21] Tobin's q represents the ratio of the market value to the replacement cost of capital, see Tobin (1969, p.21).

[22] Christensen (1971) discusses and derives this value that is commonly used ever since (Geerolf (2013)).

Bos (2007, 2013) investigates the limitations of using National Accounts in economic analysis. He argues that the derivation of National Accounts is at times detached from economic theory because it relies heavily on administrative concepts. In addition, the computation of the National Accounts varies with respect to scope, detail, quality, and frequency between countries despite international standards due to missing data and differing amounts of resources that are put into the computation of National Accounts as well as the need for approximation of certain variables. National Accounts are calculated from many heterogeneous data sources, and changing international and national standards affect the continuity and consistency of National Accounts over time, which might bias time series over a longer horizon. This greatly affects the reliability of the measures calculated from this data.

From a purely theoretical viewpoint, Barbie et al. (2001) point out that the net dividend criterion is really a criterion for pareto optimality and the sufficient conditions that have to be fulfilled are a lot more constricting than they need to be, as was already mentioned. In addition to this, Chattopadhyay (2008) identifies a mathematical flaw in Abel et al.'s (1989) proof and shows that even when the net dividend criterion is fulfilled, an economy that is not pareto optimal can be constructed.

As Geerolf (2013) uses the same criterion, most of the critique above also applies to his assessment. The net dividend criterion is thus not an optimal strategy when assessing dynamic efficiency. A criterion of the Zilcha (1990, 1991)/Homburg (2014) type eliminates the problem of using a residual size and furthermore has the bonus of being a lot less demanding. However, as will be seen later, if National Accounts are used to calculate the interest rate needed, the issues with applying such measures resurface. Nonetheless, comparing growth and interest rates is a more attractive evaluation method due to weaker assumptions. It is also the main line of argument brought up in public discussions by economists when talking about efficiency and debt recommendations, as will be shown in the next section. A comparison of interest and growth rates is therefore the dynamic efficiency evaluation technique used in this thesis.

2.2. Determining "The" Interest Rate

Now that the method of evaluation has been established, the derivation of the two rates has to be clarified. The growth rate poses a rather simple case as it will be calculated from nominal GDP data from the countries under consideration which is generally easy to obtain.

In contrast, the interest rate is a different issue, as the marginal rate of productivity is not observable and needs to be approximated using other figures. In the past, several interest rates have been used by different authors or in public debates to talk about the issue of dynamic efficiency. These shall now be presented.

To start off, a look at the current debate will be conducted. There has been some talk about the real interest rate being negative, an argument brought forward by von Weizsäcker (2014) in a recent article and Lawrence Summers (2013, 2014) at talks before the International Monetary Fund[23] (IMF) and the American Economic Association[24] (AEA). The conclusion that both draw from this assessment is that government debt should be welcomed.

The former argues that in a world without public debt, the real interest rate consistent with full employment has become negative, and the only way to ensure price stability under prosperity is to engage in government spending. He claims that the government is indeed the only agent in such an economy that could credibly run a Ponzi scheme (Von Weizsäcker, 2014, p. 50). As has already been shown in Chapter 1.4., Ponzi schemes in the form that the government can roll over a debt indefinitely, leading it to vanish in the limit, are only feasible in a dynamically inefficient economy with $r < g$. His position that the market risk-free real rate of interest is below the growth rate thus leads him to suggest that the prevailing negative view of public debt is unjustified. Summers (2014) is even clearer in his statement, arguing that in a time when $r < g$, fiscal consolidation is not only the wrong strategy, but that the "central imperative is anti-austerity, not austerity, and it has the potential to be as free a lunch as economics will ever find" (2014, 1:23:10 h). He proposes "direct fiscal policy actions" (2014, 1:17:45 h) to take advantage of the current situation and eventually induce increased investment and lower saving, reversing the trend and escaping what he calls the "modern secular stagnation" (2014, 1:03:30 h). While he repeatedly declares that his claim of a negative real interest rate is only a suggestion and not a fact, he also stresses that his theory would go far in explaining the experience of the United States after 2007.

[23] Summers (2013).
[24] Summers (2014).

In addition, he paints a rather dark picture of future economic development, including either inadequate or unsustainable growth as well as high unemployment, if the right measures are not taken up.

The situation described by von Weizsäcker (2014) and Summers (2014) is essentially a savings glut. This term was coined by Ben Bernanke (2005) and describes an excess of savings over investment. At the time, he argued that an increase in savings, primarily in emerging and developing countries, was met by insufficient investment opportunities in these countries, causing them to lend money abroad. As a result, the United States were confronted with a particularly high capital flow from other countries, which pushed down real interest rates and increased the current account deficit. However, the validity of his claim was challenged by several authors, including Laibson and Mollerstrom (2010), who show that the global savings rate did not rise during the relevant period and offer an alternative explanation based on asset bubbles. Nevertheless, the logic behind Bernanke's (2005) claim may still hold. Summers (2014) argues that a reduction in population and possibly even technological growth has reduced the demand for investment. At the same time, people tend to save more, which is the same line of argument that von Weizsäcker (2014) uses to establish his claim of an excess supply of savings over investment opportunities. If this were indeed true, low real interest rates are an indicator of a savings glut that would in turn favor the view of von Weizsäcker (2014) and Summers (2013, 2014) about a negative real interest rate.

Both of these lines of argumentation are based on describing possible symptoms or circumstances that would suggest that the real rate of interest is negative. The rate which they are referring to is a risk-free interest rate that cannot be measured properly, making it impossible to back up their claim. Their argument thus remains on the theoretical level. However, there is an observable interest rate that is usually described as being "safe" – the interest rate on government bonds. The nominal interest rate on 30-year treasury bills in the US is currently above 3%[25], which is far from zero, and even accounting for inflation, the real rate stays positive. Admittedly, as Abel et al. (1989) point out, the short-term rate has historically been below the growth rate for many countries, as several authors have shown[26], and is currently also close to zero. This is in accordance with Summers' (2014) consideration that the short-term interest rate consistent with full employment is negative.

[25] Source: Federal Reserve H15, September 2014.
[26] They cite Ibbotson (1987) and Mishkin (1984).

On the other hand, Abel et al. (1989) also explicitly state that this safe interest rate is not the relevant rate when assessing dynamic efficiency in a stochastic economy.

It is important to recall that in the theoretical model by Diamond (1965), the interest rate is equal to the marginal product of capital. In a non-stochastic model, this results in all interest rates being equal, and the safe rate on government bonds is the same as the marginal product on capital. In a stochastic environment this equality vanishes and multiple interest rates emerge. This argument is not only brought forward by Abel et al. (1989), but also repeated by Bohn (1995), Blanchard and Weil (2001) and others. They show that dynamic efficiency can still hold while the safe interest rate is below the growth rate. Bohn (1995) derives a stochastic model of an economy with a safe and a risky interest rate to examine the sustainability of budget deficits. He finds that the safe interest rate has no impact on the path of debt (Bohn, 1995, p. 266) and is thus irrelevant for the assessment of debt sustainability. Homburg (2014) develops a simulation of a stochastic stationary economy that starts out with a negative safe interest rate and a positive risky interest rate and zero public debt. Since the interest rate on government bonds is negative, a first glance might suggest that a Ponzi scheme is possible.

Contrary to this proposal, after introducing an initial debt and maintaining a primary balance in every period after that, the simulation shows that the safe interest rate will in time be repeatedly positive and the debt level will skyrocket with probability one. A successful Ponzi scheme is impossible. Homburg (2014) points out that this is due to the debt causing a decline in the capital stock, which is in turn associated with an output loss. The output loss depends on the risky rate, not the safe rate, and leads to a further capital stock reduction. The resulting vicious circle eventually leads to a collapse of the economy. This simulation emphasizes the importance of considering risky rates when it comes to assessing dynamic efficiency. The safe rate on government bonds is therefore not suitable for this undertaking.

Another argument brought forward by Summers (2014) should be investigated further as well. He argues that if the zero lower bound (ZLB) is a constraint, fiscal policy should be expanded. Eggertsson and Krugman (2012) have also claimed that nominal interest rates have reached this lower bound and come to the conclusion that government spending is necessary. The concept of the zero lower bound is that nominal interest rates cannot fall below zero. This development has taken up substantial interest in the ability of central banks to influence the economy. In times of high interest rates and sluggish growth, the interest rate is usually lowered to induce investment and thus stimulate the economy. If the interest rate is already close to zero, a further reduction to the extent needed is not possible.

This primarily relates to the interest rates that can be influenced by the central banks and is most likely the reason why the zero lower bound is mentioned by these economists. In the past years, the interest rate relevant for banks borrowing from the central bank in the United States – the Federal Funds Rate – has been close to zero. The ECB main refinancing operations rate (MRO) – the European equivalent to the Federal Funds Rate – has reached its lowest levels so far. The Federal Funds Rate has been below 1% since the end of 2008 and is currently at 0,09%[27]. On September 10th 2014, the ECB lowered the MRO to 0,05%[28]. With interest rates so low, the issue of the zero lower bound arises.

However, while it is true that short-term rates such as the overnight Federal Funds Rate have been close to zero for the past years, this does not hold for long-term rates. This can be seen in Figure 2 that compares different interest rates for the eurozone and the USA. While there is a visible downward trend in all interest rates, only the short-term interbank rates are anywhere near zero.

All other rates are still well above the zero lower bound. Contrary to Summers' (2014) reasoning, the short-term rates are not relevant for investment decisions, but rather the long-term interest rates.[29] Moreover, the Federal Funds Rate and the MRO are rates only accessible to banks, not firms or individuals, which are the relevant investors in macroeconomic models. The interest rates relevant for these agents are around 4% in the USA and around 3% in the eurozone. Therefore, as Homburg (2013) points out, the zero lower bound debate is ill-placed when intertemporal budget constraints are concerned, because it focuses on the wrong interest rates. Hence, the key interest rates such as the interbank rate of an economy are also not applicable when assessing dynamic efficiency.

[27] Source: Federal Board of Governors Database. Effective August 2014.

[28] Source: ECB Statistical Data Warehouse. Effective September 2014.

[29] At the talk before the American Economic Association, Sinn (2014) proposes another counterargument for using short-term rates: Low interest rates have been observed in Japan over the past 20 years. Yet, fiscal policy has not been able to improve the situation.

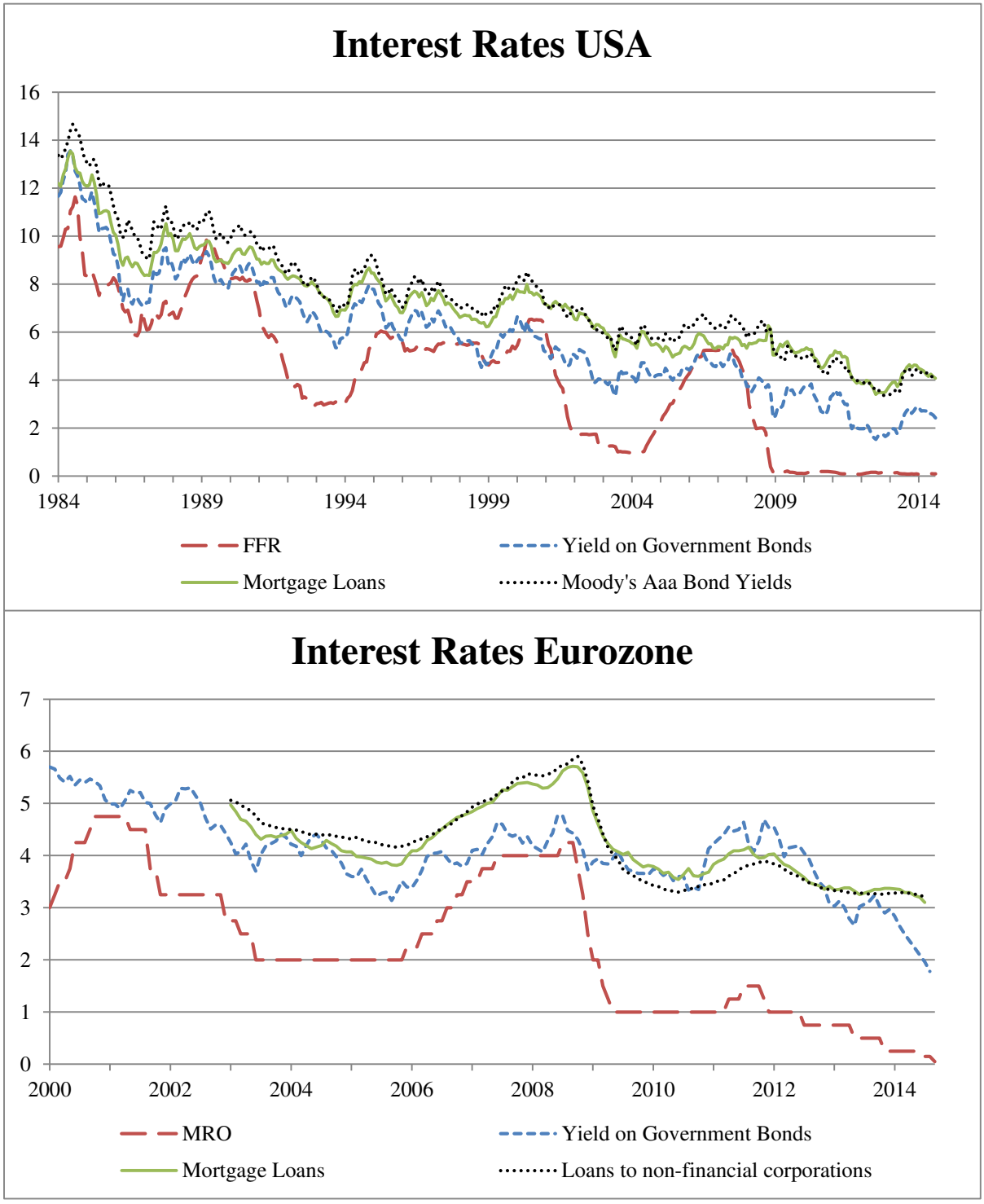


Figure 2 – Different Interest Rates for the USA (1984-2014) and the eurozone (2000-2014)

Sources:
USA: Federal Board of Governors Database –
H15/H15/RIFSPFF_N.M; H15/H15/RIFLGFCY10_N.M; H15/H15/RMMPCCFC_N.M; H15/H15/RIMLPAAAR_N.M;
Eurozone: Eurostat – Time Series irt_lt_mcby_m;
ECB Statistical Data Warehouse –
FM.B.U2.EUR.4F.KR.MRR_FR.LEV; FM.B.U2.EUR.4F.KR.MRR_MBR.LEV; MIR.M.U2.B.A2C.A.C.A.2250.EUR.N;
MIR.M.U2.B.A20.A.R.A.2240.EUR.O;
Accessed: September 2014.

As has been pointed out above, the relevant interest rate has to reflect the marginal productivity of capital. None of the main interest rates typically used as indicators in public debates – the interbank rates or yields on government bonds – suffice in approximating this figure. Several authors have therefore deduced own calculations of the return on capital and based their judgment on these estimates.

Motivated by a discussion about a possibly falling rate of profit, Feldstein and Summers (1977) develop a measure for the rate of return on capital from national account data to investigate this proposition. They calculate two pre-tax rates, a net rate of return and a gross rate of return and define the rate of return as profits of nonfinancial corporations plus total interest paid by them and divide this by the sum of the value of the fixed capital stock, the value of inventories, and the value of land, all at the end of the year. For the net rate, they use net operating profits, net interest rates and the net fixed capital stock, while for the gross rate of return they use the corresponding gross value of these measures. Increases in the value of inventories and capital gains resulting from price changes in capital or land relative to consumption goods are excluded from operating profits. The stock of fixed capital is determined by revaluing the previous fixed capital stock and adding investment. For the net rate, "economic depreciation" (Feldstein and Summers, 1977, p. 214) is subtracted, while for the gross rate an estimate of "scrapped" (Feldstein and Summers, 1977, p. 215) capital goods is deducted. They calculate the interest rates for the US from 1948-1976 and find that during that period, the net and gross rates of return have exceeded 10% in most periods. However, during the period from 1970-1976, these interest rates have dropped to an average of 7.9% (net) and 9.6% (gross). They note that while there is no clear downward trend in the interest rates over the entire period observed, there is a substantial drop in the 1970s. Nevertheless, they do believe that this is a temporary development. Feldstein (1977) later uses this data to support his claim that the United States saves too little. A higher saving only induces a higher consumption in the future if the economy is in a dynamically efficient state, as can easily be seen from Figure 1 in Chapter 1.1.. In arguing that the US would profit from higher savings, Feldstein (1977) assumes that the economy is dynamically efficient, and he bases this judgment on a comparison of the growth rate with the rate of return calculated in collaboration with Summers earlier.

As already mentioned above, Barbie et al. (2004) also use an interest rate for their assessment of the US economy. They draw on results by Mulligan (2002), who argued that "the interest rate" relevant for macroeconomic models cannot be deduced from an observed rate of a single asset, such as Treasury bill yields. Instead, he also draws on national account data to derive a measure of capital income that he then divides by capital at current cost to obtain the return on the capital stock. The capital income[30] $CapInc$ is calculated as follows:

$$CapInc = \left(Y - Y_g\right)\left[1 - \frac{W_p}{NI - W_g - Y_s}\right], \tag{31}$$

where

Y	=	real net domestic product
Y_g	=	real net product of the government sector
W_p	=	private employee compensation of domestic residents
NI	=	national income
W_g	=	labor compensation of domestic government employees
Y_s	=	proprietors' income

It is immediately visible that this calculation differs from the calculation by Feldstein and Summers (1977). His results also differ, and the rental rate on capital[31] is between 3.7-12.5% from 1900-1999.

A third calculation of the interest rate that is meant to yield a proxy for the return on capital and that has recently attracted a lot of attention is the interest rate derived by Piketty (2014). Piketty's book "Capital in the twenty-first century" establishes the claim that $r > g$ throughout most of history until the 19th century and most likely again during the 21st century (Piketty, 2014, p. 26). His calculation of r is – similar to the approaches above – a division of capital income by the national stock of capital (Piketty, 2014, pp. 201) based on National Account data. Capital income is the sum of rents, profits, dividends, interest, royalties, and other forms of annual income except for labor income. This income is pre-taxation and excludes interest on public debt. He provides graphs of these rates for Britain and France from 1770-2010 and 1820-1919, respectively (Piketty, 2014, p. 202), and explains that the rate is already a real rate (Piketty, 2014, pp. 209) due to the fact that the capital income mainly comes from "real assets".

[30] A more precise description would be the "real income to domestically employed private capital", see Mulligan (2002, p. 40).
[31] This measure is pre-direct taxes. For a further discussion on the effect of taxes, see Mulligan (2002).

However, he argues that this rate overestimates what he calls the "pure rate of return on capital" (Piketty, 2014, p. 205) due to the negligence of informal financial intermediation – the time used to manage a private portfolio – which can be compared to entrepreneurial labor. This would thus have to be deducted from the rate of return to yield the pure rate of return. Using an estimate of the cost associated with portfolio management, he finds that the pure rate of return on capital in Britain and France in the long run has stayed relatively constant around 4-5%, while estimates for the early 21st century are a little lower at 3-4%.

These three approaches all differ and consequently all yield diverse results even though similar data is used. It is difficult to say which of these rates is closest to the actual marginal productivity of capital. All rates include land rents, which as has already been pointed out is not a part of reproducible capital and should thus not be considered. Homburg (2014:3) strongly criticizes Piketty's approach of equating capital with wealth throughout his book, especially since separate data on land and capital becomes more and more accessible due to the introduction of the SNA[32] (2008). This criticism can naturally not be directed towards Feldstein and Summers (1977) or Mulligan (2002), who did not have access to this kind of data. Nonetheless, the fact that they deliberately include figures such as land, land rents, or imputed services of owner-occupied dwellings[33], when, according to Homburg (2014, p. 16), they are "not capital income in the theoretical sense", strongly suggests that the measures are quite biased. This is once more the inherent problem of calculating a rate of return based on a residual size using National Accounts that has already been described in connection with the net dividend criterion by Abel et al. (1989).

Therefore, the notion of trying to derive an interest rate that is not directly observable through such calculations will be dismissed for the analysis conducted in this thesis. Instead, a different approach is chosen, which is based on an idea introduced by Homburg (2014), who uses interest rates on corporate bonds for his test.

Taking a step back and revisiting the original Diamond (1965) model, the relevant interest rate corresponds to the marginal productivity of capital. As can be seen in Chapter 1.2., firms maximize their profit by choosing an investment strategy that uses the marginal productivity of capital as a benchmark for investment.

[32] System of National Accounts.
[33] Mulligan (2002, p. 10) explicitly states that he includes owner-occupied housing in his data on capital.

Applying this to real economies, a good measure for "the interest rate" should then be the rate that firms base their investment decisions on.[34] If firms only finance their investment using equity, the rate of return on equity would then correspond to the relevant interest rate. If, on the other hand, firms only use debt financing, the interest they pay on this debt drives investment decisions. In reality, firms usually choose a mix between these two types of financing. According to Berk and DeMarzo (2010, p. 266), debt financing is less risky than equity financing and its cost is therefore less than the cost of equity. Additionally, it is cheaper because the interest paid on debt is usually deductible from the tax base, while the cost of equity financing is not, favoring debt financing. At the same time, increasing the leverage will drive up the risk of the equity (Berk and DeMarzo, 2011, p. 464) due to additional financial distress, as pointed out by Brealey et al. (2014, p. 455). Firms thus need to find a balance between these two forces to reduce their cost of capital. The result is a firm-specific cost of capital that any investment has to earn as a minimum in order to be undertaken. An instrument to determine this threshold exists in the form of weighted average cost of capital (WACC).

Until now, the WACC have not been considered by other authors in the context of assessing dynamic (in)efficiency, as they are an instrument used by firms and not available on an aggregate national level. However, they represent the cost associated with investment better than any of the other interest rates presented in this chapter. Therefore, the WACC will be used in the analysis of this thesis to determine whether or not selected economies grow dynamically efficient. The only drawback to using WACC data is that national estimates are hard to obtain. More on this will be presented in the analysis section of this thesis in Chapter 3.1.2.. The basic concept and computation of the WACC for firms will be explained in the following section.

2.3. Weighted Average Cost of Capital

The WACC are, as pointed out by Hostettler (2000, S. 168), a standard measure for firms when assessing whether or not an investment should be undertaken. The WACC are calculated as an average of the interest rate paid on equity and the after-tax interest rate paid on debt, weighted according to the share of equity and debt, respectively.

[34] It should be noted at this point that the interest rate only corresponds to the marginal productivity of capital under the assumption of perfect competition. This might not be given in the real world. However, it is a standard assumption in macroeconomic analyses also adopted for the other approaches and dropping it would make any attempt of calculating the relevant interest rate more or less unattainable.

The WACC r_{wacc} are determined using the following calculation[35]:

(32) $$r_{wacc} = \frac{E}{E+D} r_E + \frac{D}{E+D} r_D (1-\tau_c)$$

where

E	=	market value of equity
D	=	market value of debt (net of cash)
r_E	=	equity cost of capital
r_D	=	debt cost of capital
τ_c	=	marginal corporate tax rate

While the values for E, D, r_D, and τ_c can usually be taken directly from a firm's financial statement, the equity cost of capital has to be calculated because it is not observable, as Weber et al. (2004, p. 52) state. The most common derivation of the equity cost of capital is through the Capital Asset Pricing Model (CAPM), which was first introduced by Sharpe (1964). According to Bruner et al. (1998, pp. 15) it is used by 81% of US firms and 8 out of 10 investment consulting firms. Applying the CAPM, the equity cost of capital can be calculated from[36]:

(33) $$r_E = r_f + \beta * \left(E[R_{Mkt}] - r_f\right)$$

where

r_f	=	risk-free rate
β	=	beta of the firm
$E[R_{Mkt}]$	=	expected return on the market portfolio

The term $\left(E[R_{Mkt}] - r_f\right)$ corresponds to the market risk premium and reflects the premium that investors earn due to the market risk of holding the market portfolio. β represents the risk associated with the firm i under consideration.

[35] See Berk and DeMarzo (2011), p. 596.
[36] See Berk and DeMarzo (2011), pp. 359.

It is defined as

(34) $$\beta_i = \frac{Cov(R_i, R_{Mkt})}{Var(R_{Mkt})}$$

and can only be calculated ex-post using time series on the return of the market portfolio and the firm in question. For a more detailed explanation on how β can be calculated, see Berk and DeMarzo (2011, pp. 383).

By accurately weighing the cost of different sources of capital, the WACC are used by firms when deciding whether or not to pursue a project. It is the driving factor behind investment decisions, and much more relevant for managers than macroeconomic measures calculated from National Accounts. The WACC can therefore be seen as a good approximation of the marginal productivity of capital. As this sort of data is only available at a firm-level, a national average will be derived using large numbers of firms within each country. A more detailed description on this computation will be provided in Chapter 3.1.2..

2.4. Summary

This chapter discussed the derivation of a method to assess dynamic efficiency for real economies. Methods by other authors and their limitations were considered and the net dividend criterion by Abel et al. (1989) was declared as insufficient for the purpose of this thesis, in spite of its popularity in the dynamic efficiency literature. Instead, the analysis will draw its results from comparing interest and growth rates. Next, different interest rates were examined that have been or could potentially be used. One important insight taken from this analysis is that the public debate often falsely concentrates on "safe" rates of return on government bonds or interbank rates such as the Federal Funds Rate. Economists join in and justify pushing for fiscal expansion and debt policy because these rates are below the growth rate of the economy. However, they focus on the wrong rate, which could potentially be very dangerous if their policy proposals are followed. If their assessment is wrong and the economy is indeed efficient, public debt is not a sustainable policy. The relevant rate for the assessment of dynamic efficiency is one that determines investment decisions in an economy. For firms, this is commonly measured by calculating the WACC. For that reason, the following analysis will

use WACC data to determine an average interest rate for all OECD countries as well as China and compare this rate with the growth rate of the economies.

Chapter 3: An Empirical Test of Dynamic Efficiency

"It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to suit facts."

— Arthur Conan Doyle, Sherlock Holmes: A Scandal in Bohemia (1891)

As was pointed out previously, the overaccumulation debate has gained new interest in the past couple years. Many economists like von Weizsäcker (2014) or Summers (2013, 2014) fear that the developed countries have reached a state in which the interest rate has fallen below the growth rate. In this case, Ponzi games become feasible (see Chapter 1.4.), and government debt is a popular remedy meant to make the economy better off.

The debate is held at a mostly theoretical level without a deeper look at the data available, as can be seen for example when watching the talks at the IMF or the AEA that were already discussed in Chapter 2.2.. Some authors try to develop new methods like the dividend criterion by Abel et al. (1989) that was later extended upon by Geerolf (2013). Trying to provide a better picture on overaccumulation, some of these papers' results nonetheless remain inconclusive about the state of the economy in question.

What most of these analyses fail to incorporate in their empirical assessment is that the question of dynamic efficiency – and with that, the feasibility of public debt schemes – eventually boils down to the relationship of interest and growth rates. Whereas growth rates are easy to obtain, it is a lot harder to identify the relevant interest rate for this comparison. In the previous chapters, it was made clear that safe rates on government bonds or the interbank interest

rate are not the right choice when assessing dynamic efficiency, as they do not reflect the cost of capital faced by firms. A much more appropriate instrument would be the WACC.

So far, an analysis of interest and growth rates at a national level using WACC data has not been done. This is likely due to the fact that the WACC data are not easy to obtain for this kind of examination, as Homburg (2014) points out. The analysis executed in this thesis intends to close this gap and broaden the empirical research conducted in this field so far.

The objective of this analysis is twofold. The first and more important aim is to evaluate whether or not the OECD countries[37] + China exhibit signs of overaccumulation using WACC data and growth rates. If no signs of overaccumulation are found, this presents a strong empirical case against the policy propositions by for example von Weizsäcker (2014) and Summers (2014) and support for theories such as Homburg's (1991, 1992, 2014), that overaccumulation is rendered impossible if factors like land are taken into account.

As explained before, firms usually use a mix of debt and equity financing which result in the individual WACC for each firm. It is generally assumed that equity yields a higher return than debt financing, which would mean that interest rates paid by companies for loans would have to be lower than the WACC. Such interest rates are much easier to obtain than the WACC at a national level. Homburg (2014) therefore uses these interest rates as a first test on overaccumulation for the US and the eurozone because they correspond to a lower bound on the WACC, in theory. Whether or not this assumption is correct will also be tested in this analysis for several eurozone countries and the US. If it holds and the WACC are always higher than the interest rates paid by non-financial institutions for debt financing, a first assessment of overaccumulation using only interest rates is possible. If the result points to overaccumulation, a further test with the WACC will help clarify the picture. However, if the interest rates exceed the growth rate already, then so will the WACC and thus there will be no case for overaccumulation. Looking at these easily obtainable interest rates and growth rates can then be used as a "pre-test" whether or not the economy grows inefficiently. Evaluating the reliability of such a pre-test is thus the second objective of the analysis.

[37] Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, South Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, USA.

3.1. Data Sources and Calculations

The data used in this thesis was collected from several sources[38]. It includes data on the WACC, the growth rate and in some cases the interest rate paid by non-financial corporations. The WACC data was obtained at a semi-annual basis from 30.06.2000-30.06.2014. All other values were collected at a monthly or quarterly basis and then converted to represent comparable semi-annual values.

The countries considered in this analysis are all 34 OECD countries as well as China to examine a wide variety of big as well as small economies across the globe that are at different stages of their economic development. In addition, data on the aggregates EU12[39], the EU17[40], and OECD + China was considered. The EU12 consists solely of OECD countries for which the data was collected. The EU17 includes Malta and Cyprus that are not OECD countries, so no WACC data was collected for these two countries. They are thus only reflected in the growth rate of the EU17. As these countries play a rather small role in the euroarea and there is no reason to assume that their WACC data should differ significantly[41] from the other countries, this should not affect the results to a great extent.

3.1.1. Growth Rate

For the growth rates, quarterly data on the nominal GDP from the OECD database[42] was used, more specifically the GDP obtained via the expenditure approach (B1_GE), measured in millions of national currency at current prices, quarterly levels and seasonally adjusted (measure: CQRSA). Quarterly data from the first quarter of 1999 until the second quarter of 2014 was taken. The first two quarters of each year were then added to get the GDP of the first half year; the quarters III and IV make up the second half year. From these values, a year-over-year (yoy) calculation yielded the annual growth rates of the economies at six-months-intervals. The following calculation was used:

[38] Bloomberg, ECB, Eurostat, Federal Reserve Board database, OECD, Penn World Tables.

[39] Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain

[40] Austria, Belgium, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, Spain, Cyprus

[41] Significantly in this context is to mean that they differ enough to affect the general form of the WACC curve for the EU17 countries, e.g. pushing it below the growth rate.

[42] Available at http://stats.oecd.org/. Accessed 07/24/2014.

(35) $$g_{I_t} = \left(\frac{GDP:I_t}{GDP:I_{t-1}} - 1 \right) * 100 \quad \text{and} \quad g_{II_t} = \left(\frac{GDP:II_t}{GDP:II_{t-1}} - 1 \right) * 100$$

$$\text{for} \quad t = 2000, 2001 \ldots, 2014$$

where g_{I_t} is the growth rate for the first half year and g_{II_t} that of the second with GDP:I being the GDP of the first and GDP:II that of the second half of year t.

For some countries quarterly data was not available. This concerns Greece, China, EU12, and EU17 for the whole period and Korea and Luxembourg for the year 1999. For Greece, China and EU17 as well as Korea and Luxembourg, annual data from the OECD database for the GDP was used to calculate the annual growth rate at an interval of one year instead of six months. This does not change the results much; it only means that for these calculations the growth rate g does not show as many details of the growth path of the economy. China's GDP for the year 2013 is not yet available. For the EU12 the OECD doesn't collect any data. Instead, data on the time series of annual GDP at current prices (B1GM) for the EU12 area from Eurostat[43] was used. Again, data starting in 1999 was collected to obtain growth rates starting in 2000.

When determining an average for the entire time frame under consideration, a geometric mean was calculated as is the standard procedure when averaging growth rates over a horizon.

3.1.2. WACC

It was already explained that the WACC are a financial instrument used by firms and therefore not available for nations as a whole. There have been some efforts to calculate the cost of capital for countries in the past[44], but as there were only very few and for different time horizons, they are not sufficient for the analysis conducted in this thesis. Therefore, the WACC need to be obtained differently. There are different approaches to doing this. One possibility would be to estimate the different elements for the country as a whole, like Friend and To-

[43] Available at http://epp.eurostat.ec.europa.eu.

[44] Krotter (2003) calculates the WACC for all firms in the German DAX, MDAX, and SDAX, and although he does not do this in order to derive a national value for the WACC, he presents an average of all firms from 1988-2000 that could be interpreted as a national estimate of the WACC. Ando and Auerbach (1988) measure the cost of capital for Japan and the United States from 1967-1983, though they do not use the WACC approach. Similar to Krotter, they draw on data from large samples of firms. Friend and Tokutsu (1987) focus on Japan and the US economy as well, calculating a measure of the cost of capital – again not according to the standard WACC approach – using estimates for the different components from 1962-1984.

kutsu (1987). Another would be to approximate the figures using information of many firms within a country and calculating an average from this data, either for the elements of the WACC formula or for the WACC directly. The former heavily relies on assumptions and estimates, while the later incorporates actual data that directly represents firms' cost of capital. In this thesis, the second approach is therefore used and firm data on the WACC is acquired at a large scale.

The WACC data was obtained from the Bloomberg database. The Bloomberg database collects financial and economic data for more than 600.000 companies in 117 countries.[45] They started collecting the WACC data for companies in the year 2000, which thus constitutes the start of the time series under investigation in this thesis. The data from the database was taken for two dates each year, the 30th of June and the 31st of December. For each country under consideration, the biggest and/or most important stock market was selected and the WACC data for all companies in that stock market was collected. The only exception was Italy, for which no data could be obtained at all. Table 2 reports the stock market used for each country and the number of companies in each of these markets.

However, WACC data was not available for all companies and not at all times and the size of the stock markets vary quite strongly as can be seen in Table 2. Therefore, for some countries the time series doesn't start until later, for example Hungary for which the first data is available on 30th June 2002 and at that point only for four companies. Slovenia's first company starts reporting their WACC data at the end of 2003 and it is not until 2008 that all companies in the stock market collect the WACC data. For all countries, the number of companies where the WACC are reported increases over time. The implications this has on the reliability of the data to reflect a country's WACC will be discussed in Chapter 4.2..

[45] http://www.bloomberg.com/enterprise/data/reference-data-services/.

Country	Stock Market	No. of members	First WACC data collected
Australia	S&P/ASX 300	297	30.06.2000
Austria	ATX	20	30.06.2000
Belgium	BEL 20	20	30.06.2000
Canada	S&P/TSX Composite Index	251	30.06.2000
Chile	IPSA Index	40	30.06.2000
Czech Republic	CTX Index	14	30.06.2000
Denmark	OMX Copenhagen 20	20	30.06.2000
Estonia	OMX Tallinn Index	16	30.06.2000
Finland	OMX Helsinki All Share Index	130	30.06.2000
France	CAC 40	40	30.06.2000
Germany	DAX, MDAX, SDAX	130	30.06.2000
Greece	Athens Stock Exchange General Index	60	30.06.2000
Hungary	Share Index of Budapest Stock Exchange	14	30.06.2002
Iceland	NASDAQ OMX Iceland	14	31.12.2000
Ireland	ISEQ Overall Index	48	30.06.2000
Israel	TA-100 Index	101	30.06.2000
Italy	–	–	–
Japan	Nikkei 225	225	30.06.2000
South Korea	KOSPI	762	30.06.2000
Luxembourg	LuxX Index	10	30.06.2000
Mexico	IPC	35	30.06.2000
Netherlands	AEX	25	30.06.2000
New Zealand	NZX All	115	30.06.2000
Norway	OBX Index	25	30.06.2000
Poland	WIG 20	20	30.06.2000
Portugal	PSI 20	20	30.06.2000
Slovakia	SAX Index	7	31.12.2000
Slovenia	SBITOP	8	31.12.2003
Spain	IBEX 35	35	30.06.2000
Sweden	OMX Stockholm 30	30	30.06.2000
Switzerland	SMI	20	30.06.2000
Turkey	ISE-100 Index	99	30.06.2000
United Kingdom	FTSE 100	101	30.06.2000
USA	Russell 1000	1031	30.06.2000
China	CSI 300	300	30.06.2000

Table 2 – Stock Markets of OECD countries and China

Stock markets and number of members for all OECD countries and China considered in this analysis. WACC data was collected for all companies in these markets between 30.06.2000 and 30.06.2014, if available.

Source:Bloomberg, Accessed 07/07/2014.

Bloomberg's own calculation is based on the basic formula (32):

$$r_{wacc} = \frac{E}{E+D} r_E + \frac{D}{E+D} r_D (1-\tau_c) \tag{32}$$

As Sharfman and Fernando (2008) point out, the WACC calculated by Bloomberg may differ from other calculations in two aspects. The beta factor is calculated by Bloomberg and provided on a weekly basis as opposed to e.g. COMPUSTAT's annual beta. They also use a firm-specific risk premium that they estimate themselves instead of using, for example, the Fama and French (2002) estimate of the risk premium that is used by Sharfman and Fernando (2008). Again, implications will be discussed in Chapter 4.2..

For each point in time, a simple arithmetic average for all companies within one country was calculated. The companies were not weighted but instead were all considered equally for several reasons. One of them has to do with the fact that if one would weight the WACC, for example, according to the company's share in the market, this would lead to problems of calculating the average value when there are no WACC values available for several companies in the stock market. As previously stated, the availability of WACC data for each stock market varies over time, which would then mean that for almost all periods, the WACC weights would have to be recalculated. If that were to be done, the weights would no longer reflect the market share properly and consequently they would lose their meaning. This goes for all other ways of weighting the WACC with respect to market data. Additionally, not weighting the companies allows the average WACC value to reflect the WACC of big or small companies to the same degree, which is exactly what one would want them to at a national level. Calculating arithmetic means for each date then yielded the time series for the WACC of each country.

As with the growth rates, when calculating the average WACC data over the whole horizon under consideration a geometric mean was determined to reflect the average WACC for one country.

3.1.3. Interest Rates

For the eurozone, interest rates on loans were used, whereas for the United States bond yields were obtained. This is owed to the fact that while European firms prefer loan financing, US firms favor bond financing, as Homburg (2014) points out.

The data on the interest rates for the euroarea countries was obtained from the ECB statistical data warehouse[46]. The time series "MIR" (Monetary Financial Institution Interest Rates) was filtered for loans to non-financial corporations (sector S11) for all countries in the euroarea. The ECB provides a time series for monthly annualized agreed rates for different maturities. For this study, only the interest rates for total original maturity were considered. The exact series key for each country can be found in Appendix 1. For most countries, this time series starts in 2003 when a new calculation of the MIR was introduced. For some countries the time series does not start until later.

For the United States, the H.15 data from the database of the Federal Reserve Board[47] was obtained. The interest rates used for this study were Moody's Aaa corporate bond yields, which are available at a monthly basis starting in 1919. The Aaa yields were used because they correspond to a lower risk premium compared to the Bbb yields. This also means that the Bbb yields will be higher than the Aaa yields. Using the Aaa yields thus leads to a stronger result if they turn out to exceed the growth rate, because then all rates for companies with a lower ranking will be even higher.

The monthly data had to be converted to semi-annual data. This was again done using a geometric mean calculation.

3.1.4. Combining countries

[46] Available at http://sdw.ecb.europa.eu.
[47] Available at http://federalreserve.gov/releases/h15/data.htm.

In addition to the analysis of single countries, an analysis for the EU12, the EU17 and all countries considered (OECD + China) together was carried out. One could have manually added the GDP of the countries under consideration and calculated the growth rate from the sum of all GDP.

Instead, the GDP necessary for the calculation of growth rates for the EU12 and EU17 were already provided by Eurostat and the OECD, enabling a direct calculation of the growth rates.

For the WACC data, the calculation was not as straightforward. Instead of simply averaging the WACC data of all countries for each point in time using an arithmetic mean, it now makes sense to weight the WACC when aggregating all countries. Otherwise a country like Slovenia has the same impact on the calculation as the United States, even though the US economy is almost 300 times as big as Slovenia's[48] and the data on the WACC for the US is more extensive than the data for Slovenia. Additionally, the growth rates calculated from aggregating the GDP values have the effect of weighting each country's growth rate according to the GDP. Hence, one needs to weigh the WACC as well in order to guarantee equal treatment of the two rates.

The countries were weighted according to their economic output, represented by their GDP share in the base year 2000 taken from the Penn World Tables[49]. The Penn World Tables provide PPP-converted[50] data on the GDP of all countries, ensuring that the data is not distorted. The GDP of all countries analyzed in this thesis was added and the percentage of each country's GDP relative to the total GDP of these countries was equated with the weight. These weights were also used when calculating the growth rate for the OECD + China table, as there was no aggregate available for the GDP of this area in half-annual intervals.

The Penn World Tables provide two time series for the GDP in China. For this calculation, the China2 time series was used as it is better suited for recent data. In the case of Italy where no WACC data could be obtained the interest rate provided by the ECB was used. Naturally, for the EU12 and the EU17 time series the weights were recalculated, using only the countries under consideration, though Malta and Cyprus were dropped completely from the EU17 WACC estimate.

[48] Measured by the PPP-GDP provided by the Penn World Tables for the year 2000.
[49] Available at https://pwt.sas.upenn.edu/.
[50] PPP stands for „purchasing power parity".

3.2. Results

Out of the 35 countries under consideration, only six exhibit signs of overaccumulation when comparing the average WACC and the average growth[51] rate from 2000-2014. The results for these countries will be presented further before moving on to the results for the other countries, which can be divided into three additional categories. The second category that will be presented consists of countries where the WACC exceed the growth rate in almost all periods, but the growth rate never crosses the WACC more than once. If interest rates are available, they also exceed the growth rate on average. The third category is made up of countries where the WACC indicate dynamic efficiency, but the interest rates for non-financial corporations suggest inefficiency. The last category encompasses all countries where the WACC on average indicate dynamic efficiency, but where the growth rate exceeds the WACC several times or for long periods of time.

Selected graphs for each category will be presented as examples. Due to the fact that the aim of this thesis is not to provide a complete explanation of the growth behavior and its drivers for each economy, detailed descriptions of all of these economies will not be given. An exception is made for the countries that indicate dynamic inefficiency, because these will be looked at more closely in the following discussion. For the other categories, the focus will be on common characteristics important for the assessment of dynamic efficiency. Nonetheless, graphs for all countries and aggregates can be found in Appendix 2.

3.2.1. Category I

According to the comparison of WACC and growth rates China, Chile, Estonia, Iceland, Slovakia, and Turkey show signs of overaccumulation as their growth rate exceeds the WACC on average. For Estonia and Slovakia the interest rates paid by non-financial corporations i is on average also lower than the growth rate g. Table 3 summarizes the values for the average WACC, growth rates, and interest rates, if available.

[51] Both geometric means as explained earlier in Chapter 3.1.

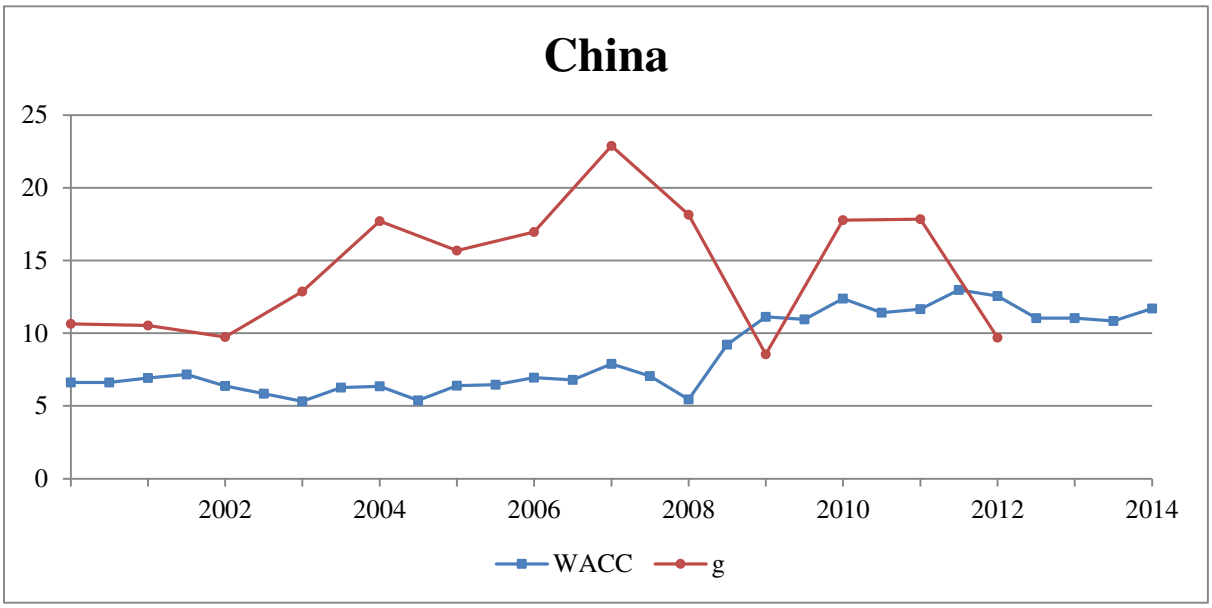
Country	WACC	*g*	*i*
China	8.14	14.46	–
Chile	7.49	9.54	–
Estonia	7.74	8.92	4.46
Iceland	5.74	7.88	–
Slovakia	5.33	6.78	3.91
Turkey	8.15	21.01	–

Table 3 – Category I: Average Data for WACC, Growth Rates, and Interest Rates, collected 2000-2014

Source: As described in the text. Own Computation.

For these countries, the growth rate falls significantly in 2008/2009 and drops below zero in all cases but China. Immediately afterward, the growth rates rises again quickly, only to fall again within the next year. China is the only country to reach the same growth rate at the end of the analyzed period that they had at the beginning in 2000.

However, for China this is also the lowest level of growth at about 10%, which they reach at the beginning of the millennium and then again in 2009 and 2012. During the rest of the period considered, growth rates are significantly higher, peaking at roughly 23% in 2007. The WACC are between 5-8% until the summer of 2008. After that, they rise to a level of 9% and



have since stayed relatively constant between 9-13%. Except for the years 2009 and 2012, the growth rate always exceeds the WACC. Figure 3 shows the case of China as an illustration of overaccumulation. Graphs for the other five countries can be found in the Appendix 2.1..

Source: As described in the text. Own Computation.

Chile starts out with a growth rate slightly above 10% that falls at first but then climbs to over 18% in 2004. It then decreases for two half-years before peaking slightly above 19%. In 2007, it plunges to at first 8% and then even becomes negative in 2008:II and 2009:I. The GDP immediately reverts back to high growth rates (13-16%) before plummeting again in the second half of 2011, growing between 5-7% since. The WACC mostly increase from 2000-2014 from a level of almost 7% to 10% in 2014, with a small setback between 2011-2013 where they fall from 10% to around 8%. The growth rate exceeds the WACC most of the time between 2000 and 2014. It only falls significantly short of the WACC in 2008:II, 2009:I and since 2011:II.

Estonia starts out with a fairly high growth rate (15%) that reaches its maximum at slightly

Figure 3 – China: Empirical Comparison of WACC and Growth Rate, 2000-2014

below 22% in the first half of 2007. In 2008 it drops to 6% in the first half and -3% in the second half. In 2009, the growth rate is as low as -14%. The economy recovers fast, reaching a growth rate of 8% in the second half of 2010 and even 14% in 2011. Since then the growth rate has decreased somewhat and is now at a little over 5%. The WACC stay relatively constant between 5-8% until the second half of 2010, where they skyrocket to over 17% for one year. Since the second half of 2011, the WACC have stayed between 9-13%. Prior to 2008, the growth rate exceeded the WACC significantly. After 2008, the opposite is the case. The time series for the interest rate doesn't start until 2008. The interest rate is always lower than the WACC and drops slowly from 6% slightly below 3% over the course of 6 years.

Iceland's GDP exhibits strong fluctuations, with a growth rate between 14-16% in 2001, 2004, 2006, and 2008. After each period of strong growth, the growth rates plunges within the next one or two periods by at least 4 percentage points. In 2001, it drops from almost 15% to less than 3% within a year, from 2008 to 2010 the fall is even more drastic from close to 15% to almost -1%. Contrary to the growth rate, the WACC stay comparatively constant between 4-8% over the entire time series. As opposed to the China, Chile, and Estonia, the WACC are on average lower between 2008-2014 (4-5.5%) compared to the period from 2000-2008 (5-8%). They only exceed the growth rate between 2002:II-2003:II, 2009:I-2011:I, in 2012:II-2013:I and in 2014:I.

The growth rate in Slovakia starts out fluctuating between 7-13% until 2008 where it drops to 5% and then to almost -7% in 2009. The recovery starts in 2010 when the growth rate rises sharply to about 5%. Since then it has decreased and is currently only a little below 2%.

The WACC start out at 6% and stay relatively constant until the summer of 2008 with the exception of the second half of 2001 and the first half of 2002 where the WACC are above 8%. After 2008, the WACC have mostly declined and reach values between 3-5%. The interest rate for non-financial corporations starting in 2006 is below the WACC for all years but 2014, where it is 0.23 percentage points higher. From 2006-2008 it is between 4-5.5%, whereas after it always stays between 3-4%. The growth rate falls short of the WACC in 2001:II-2002:I, 2009, and since 2012:I.

Turkey exhibits the highest growth rates of the entire data set, starting out with a growth rate of over 66%. This rate plunges to 40% within a year, and even after climbing again somewhat for one year it drops to even lower levels, reaching its minimum in the first half of 2009 with a growth rate of -3%. It reverts back to a growth rate between 10-20% but suffers one more fall in 2012. The WACC vary in a wide range between 5-13% over the entire time horizon, however, there are barely any strong fluctuations and the movement from 6,5% in 2000 to 13% in 2014 is rather smooth. They exceed the growth rate between 2008:II-2009:II and since 2013.

3.2.2. Category II

This category includes all countries where the WACC are almost always greater than the growth rate and where the interest rate – if available – is on average also greater than the growth rate. This applies to Austria, Belgium, Denmark, France, Germany, Italy, Japan, Netherlands, Portugal, Sweden, Switzerland, UK, USA, and the combinations EU12 and EU17. Table 4 summarizes the values for the average WACC, growth rate, and interest rate.

Country	WACC	*g*	*i*
Austria	7.11	3.42	3.48
Belgium	6.92	3.42	3.99
Denmark	7.65	3.05	–
France	7.86	2.95	3.85
Germany	7.52	2.26	4.30
Italy	–	2.27	4.22
Japan	6.94	-0.31	–
Netherlands	7.96	3.15	4.03
Portugal	6.89	2.59	4.60
Sweden	8.00	3.82	–
Switzerland	7.75	2.73	–
UK	8.51	4.26	–
USA	8.83	4.01	5.42
EU12	6.48	2.82	4.10
EU17	6.47	2.87	–

Table 4 – Category II: Average Data for WACC, Growth Rates, and Interest Rates, collected 2000-2014

Source: As described in the text. Own Computation.

For all of these countries, a plunge in the growth rate in 2009 to negative values can be observed. Even before that, the movement of the growth rate shows striking similarities. Prior to 2009, a dip in the growth rate between 2001 and 2004 is clearly visible. After the crash of growth rates in 2009, all countries recover quickly and even reach pre-crash-values in most countries. This lasts until 2011 where growth rates begin to plummet again. The rise in growth rates in 2010 coincides with a rise in the WACC for all countries except for Portugal, where the increase can be observed in 2011. In most of these countries, the WACC reach their maximum at this point and then decline again, for some countries slower than for others. Where interest rates are available, they remain below the WACC for all countries at all times except the USA in the year 2000. In the case of Italy and Portugal, the interest rates also exceed the growth rate in all periods. For all other countries, the interest rate sometimes falls short of the growth rate. Nevertheless, it is greater than the growth rate on average. Figure 4 shows the graph for the EU12 combination, the USA, and Japan. All other countries can be viewed in Appendix 2.2..

The EU12 graph, even though it contains data on countries that are not in this category[52], nicely represents the movement of the curves for all the countries in Europe within this category, including countries that are not in the euroarea. As these movements are fairly similar, the EU12 was chosen to illustrate the graphs of all European countries. The US economy as one of the economies often studied by other authors (see Chapter 2) is also included here. The margin between the WACC and the growth rate is clearly visible. In the case of Japan, the characteristically low growth rate inherent to the Japanese economy since the "lost decade" in the 1990s can be seen nicely[53].

[52] Finland, Greece, Ireland, Luxembourg, Spain.

[53] For more on Japan's "lost decade", see Hayashi and Prescott (2002).

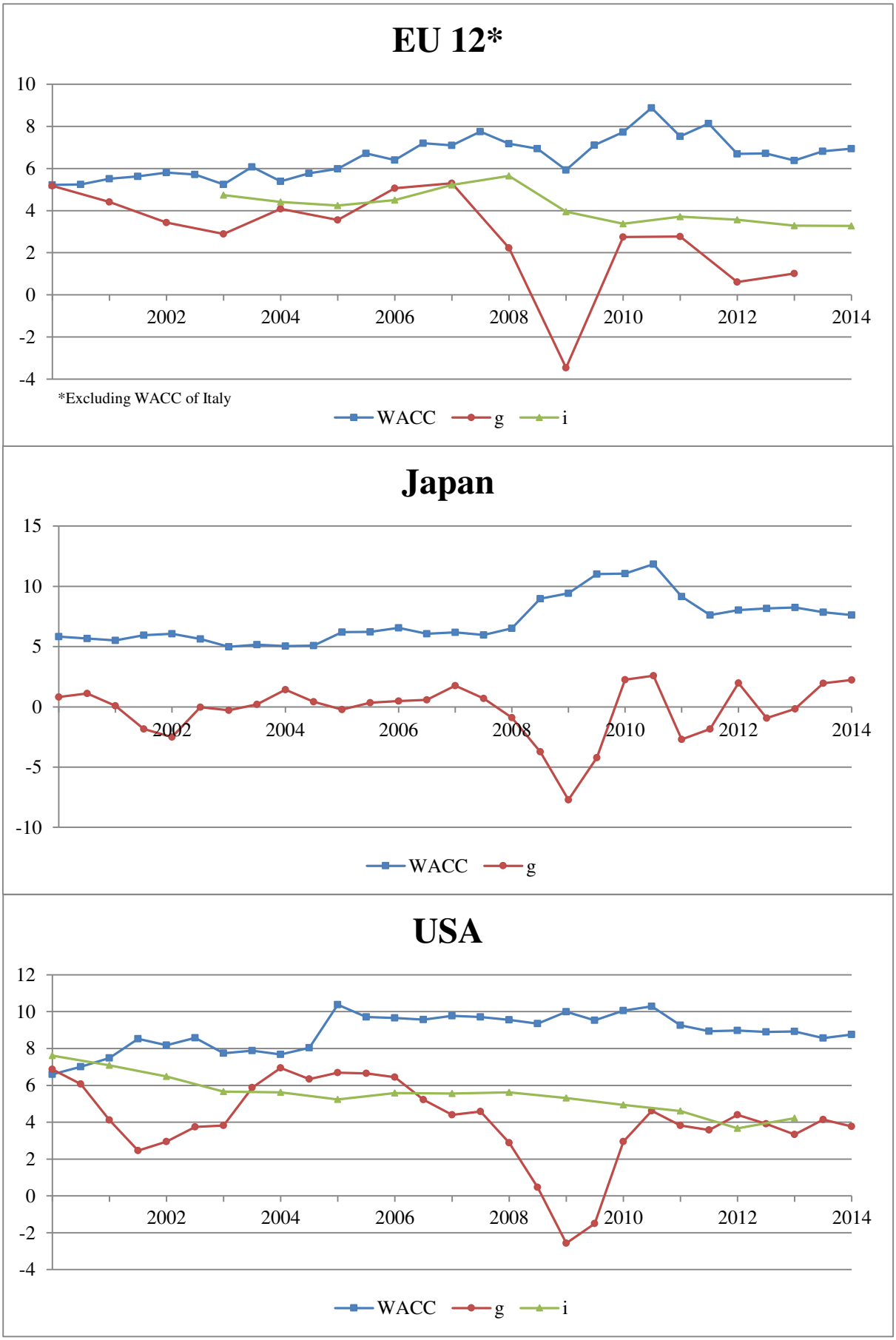


Figure 4 – EU12 / Japan / USA: Empirical Comparison of WACC, Growth Rate, and Interest Rate 2000-2014

Source: As described in the text. Own Computation.

3.2.3. Category III

In the case of Finland, Ireland, Luxembourg, Slovenia, and Spain, a look at the WACC and the growth rate on average would indicate dynamic efficiency. In contrast, the interest rate on loans for non-financial corporations falls short of the growth rate on average, indicating dynamic inefficiency. Table 5 presents the average values for WACC, growth rates, and interest rates.

Country	WACC	*g*	*i*
Finland	6.98	3.35	3.08
Ireland	7.89	4.7	4.09
Luxembourg	7.26	5.43	3.38
Slovenia	7.34	5.42	4.59
Spain	7.21	4.01	3.81

Table 5 – Category III: Average Data for WACC, Growth Rates, and Interest Rates, collected 2000-2014

Source: As described in the text. Own Computation.

With respect to the specific evolution of the different rates, the countries differ significantly. However, the most important features for this analysis will be pointed out now. All graphs can be found in Appendix 2.3., while the case of Spain and Ireland, which are both part of the GIIPS[54] countries, are also shown in Figure 5.

Once again, a significant drop in the growth rates to negative values in 2008/2009 can be observed for all countries, Ireland and Luxembourg starting in 2008 and the other countries following in 2009. Growth rates recover after that but begin to drop again; Slovenia, Ireland, and Spain reaching negative growth rates once more. With the exception of Luxembourg in 2011:I, the WACC exceed the growth rate in all countries since 2008:II. The interest rate is always lower than the WACC for all countries during the time observed.

[54] Common name for Greece, Italy, Ireland, Portugal, and Spain. During the euro crisis these countries had particularly high public debt levels.

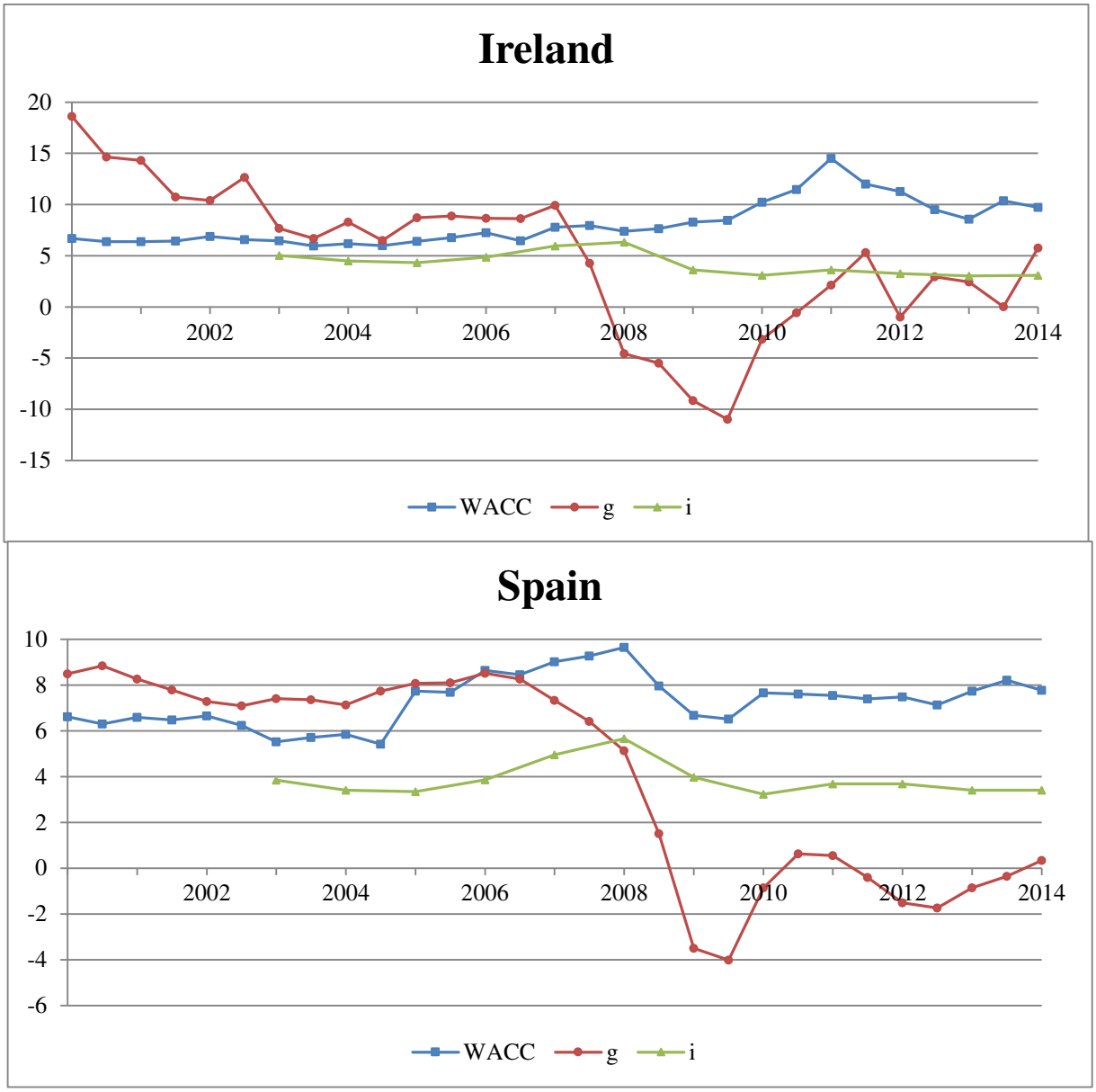


Figure 5 – Ireland / Spain: Empirical Comparison of WACC, Growth Rate, and Interest Rate 2000-2014

Source: As described in the text. Own Computation.

3.2.4. Category IV

This category encompasses all countries where the WACC exceed the growth rate on average, indicating dynamic efficiency, but the growth rate exceeds the WACC on several occasions or for extended periods of time.

These countries are Australia, Canada, Czech Republic, Greece, Hungary, Israel, South Korea, Mexico, New Zealand, Norway, Poland, and the OECD + China analysis. Table 6 gives the average WACC, growth rate, and interest rate, if available.

Country	WACC	*g*	*i*
Australia	8.22	6.67	–
Canada	6.92	4.60	–
Czech Republic	6.79	4.42	–
Greece	7.43	2.72	5.81
Hungary	8.13	6.91	–
Israel	7.26	5.65	–
South Korea	7.79	6.48	–
Mexico	8.68	7.84	–
New Zealand	7.27	5.18	–
Norway	8.77	6.48	–
Poland	8.43	6.67	–
OECD + China	7.79	5.12	–

Table 6 – Category IV: Average Data for WACC, Growth Rates, and Interest Rates, collected 2000-2014

Source: As described in the text. Own Computation.

Other than exhibiting WACC that are on average higher than the growth rate, the countries behave quite differently. Two characteristics common for almost all countries in this category are noteworthy. With the exception of Israel in 2012:II and Mexico from 2010-2012, the WACC always exceed the growth rate after 2008:II. Once again, the financial crisis in 2008/2009 can be clearly seen in almost all countries, Israel being the only notable country showing no signs of recession. As an illustration, the graphs for Greece as a special case and for the OECD + China analysis are also depicted in Figure 6. Greece shows an unusually high value of over 39% for the WACC in 2011:II. The graph for all countries as a whole shows that the WACC exceed the growth rate almost all the time except for 2000 and 2004. The gap between the WACC and the growth rate becomes especially visible during 2008/2009 and remains larger after the crash than before. All other graphs can be found in Appendix 2.4..

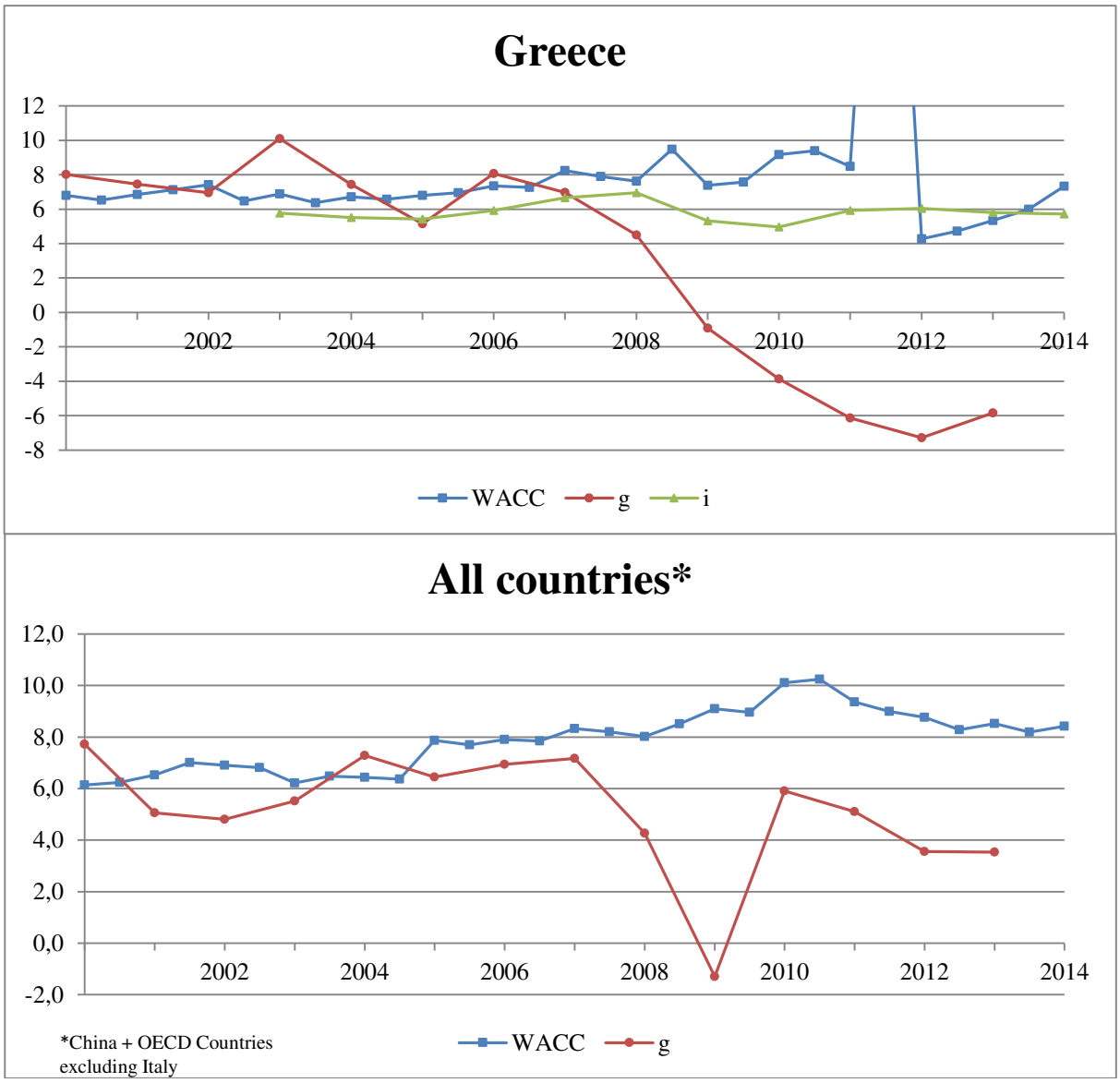


Figure 6 – Greece / OECD Countries + China: Empirical Comparison of WACC, Growth Rate, and Interest Rate 2000-2014

Source: As described in the text. Own Computation.

3.2.5. Summary

To sum up the results from the different countries, it can be seen that almost all countries exhibit a rapid fall in the growth rate as a result of the financial crisis in 2008/2009. Even though growth rates quickly recovered, they have declined again ever since. In contrast to the often fluctuating growth rate, the WACC have remained relatively constant. As can be seen in Figure 6, which combines all countries under observation, there was a slight increase of the average WACC over the time period considered. The average growth rate exceeds the average WACC in only 6 countries.

Chapter 4: Discussion

The reason for the comparison of the WACC and the growth rates was to investigate the dynamic efficiency properties of the OECD countries + China. Recently, two leading economists – von Weizsäcker (2014) and Summers (2013, 2014) – have suggested that some of these economies display characteristics that call for government intervention. They propose public debt to fix problems inherent to the economies. However, this policy is never feasible if the economy is on a dynamically efficient growth path. A "free lunch" as proposed by Summers (2014) is only attainable in a state of inefficiency. Otherwise the debt cannot be rolled over indefinitely: it has to be served sooner or later. It is therefore necessary to establish if the economies in question are in fact inefficient or not, which is equivalent to saying that the growth rate surpasses the interest rate – represented here by the WACC – in the limit. For empirical assessments, the average rate serves the purpose of indicating the eventual behavior under the assumption of ergodicity, meaning that the average behavior represents the behavior over the entire horizon. The last chapter presented the results from this analysis. A discussion of these findings and the feasibility of the pre-test will now be conducted.

4.1. Are the OECD Countries and China dynamically inefficient?

A first look at the data clearly shows that for some countries, the growth rate exceeds the WACC on average, indicating dynamic inefficiency according to the criterion described in Chapter 1.3.. This applies to 6 out of the 38 examinations, just a little over 15% of the sample. For all other economies as well as the EU12 and EU17, overaccumulation can be rejected. Combining all countries yields the same result, indicating that the OECD countries + China as a whole grow efficiently.

One result that is noteworthy before taking a closer look at the different countries is the fact that the average WACC over the time period considered are fairly similar across countries, ranging from 5.33% to 8.83% with an overall average of 7.79%. This supports a claim by Caselli and Feyrer (2007) that the marginal cost of capital are essentially equal across countries. The way they derive this result is also interesting for the analysis in this thesis.

They first use a simple estimate of the marginal product of capital by employing data from the National Accounts and divide an estimate of the capital share of the GDP by the capital stock.

This is very similar to some of the measures discussed in Chapter 2.2.. They find that with this estimate, there is indeed a visible difference between developing and developed countries. However, after adjusting their estimates for land and other natural resources as well as price differences between capital and consumption goods, this difference all but vanishes. The fact that the average WACC across countries do not differ to a great extent not only supports their results, but furthermore stresses the importance of excluding land data from the calculation of the return on capital and including other adjustments, should National Accounts data be used. Failing to do so will inevitably bias the results and potentially lead to a wrong assessment. The WACC being fairly similar across countries also suggests that the marginal productivity of capital is independent of the development stage of an economy and will stay roughly the same as a country advances. What is more, there is no apparent correlation between the movement of the WACC and the movement of, for example, government bond yields or the interbank rates. This underlines the inadequacy of using the latter to argue about dynamic efficiency.

For the remainder of the discussion it is important to keep in mind that for dynamic efficiency, only the eventual behavior of WACC and growth rate decides whether or not an economy is actually inefficient. Since the analysis not only focuses on developed countries but also a variety of emerging market economies, lessons drawn from the former might therefore be applicable to the latter. This being said, the different categories already presented in Chapter 3.2. will now be examined further.

Separating the countries into groups according to their behavior quickly shows a certain pattern. All countries in category II, the countries that show no sign of inefficiency with respect to their WACC and interest rates, are industrialized and advanced economies, whereas the countries in category I are categorized by e.g. the IMF as mostly emerging markets or frontier markets. Category III and IV consist of both emerging and advanced economies.

Category I contains countries that exhibit signs of overaccumulation, so public debt could in these cases make everyone better off – in theory. However, before this is taken as a direct invitation to accumulate more debt, a closer look at the economies in question is important. As mentioned before, the WACC data do not differ much across countries and stay relatively constant over time. This uncovers the growth rate as the driving factor behind inefficient growth paths. If the WACC constantly remain at a high level over time, dynamic inefficiency only becomes possible due to high growth rates.

For the moment, the countries under consideration in category I seem to have accumulated too much capital. On the condition that these economies were to stay in this state indefinitely, public debt would be feasible. If on the other hand growth rates can be expected to decrease and fall below the WACC sooner or later, the accumulated debt will instead turn into a burden for the economy. An assessment taking expected future developments into consideration is especially crucial in these cases.

One of the main characteristics of emerging markets is that they exhibit high growth rates compared to advanced economies. They are transitioning from being developing countries to developed countries, and the introduction of (better) infrastructure and stability, especially on the credit markets, boosts economic growth. Most of the now advanced economies have also undergone this process several times. Especially for European countries, high growth rates after World War II can be observed. An analysis similar to the one conducted here might have indicated dynamic inefficiency for these countries several decades back. However, over the years, economic growth slowed. This behavior is also expected from emerging countries in the future.[55] China, Chile, Estonia, Slovakia, and Turkey – five of the six countries that show signs of overaccumulation – are officially recognized as emerging market countries by the IMF World Economic Outlook of 2008 (IMF (2008)). The World Economic Outlook of 2014 (IMF (2014)) characterizes Estonia and Slovakia as advanced economies. As they were still classified as emerging markets six years earlier, this distinguishes them from Iceland which has long been among the advanced countries.

Therefore, for all countries but Iceland, it can be expected fairly certain that the high growth rates will decline in the future, a trend that is already visible in Turkey, Estonia, and Slovakia, where growth rates have decreased significantly compared to their level in 2000. Before introducing new debt programs in these countries because they show signs of inefficiency now, one should therefore wait a few years and repeat the analysis of interest and growth rates with more data. If the recent trend continues, a new assessment will quite likely produce a different result.

If or when this downward trend in growth rates will reach China and Chile is unclear. Eichengreen et al. (2012) investigate former fast-growing countries and the nature of their slowdowns to draw conclusions for currently fast-growing economies, especially China.

[55] The dynamics of economic catch-up have been famously investigated by Gerschenkron (1962). It is inevitable that at some point – at the latest when there is nothing more to catch up to – important drivers behind this type of growth will weaken significantly. Continued high growth is not achievable forever, see also Eichengreen et al. (2012, p. 43).

They find that significant slowdowns in the growth rate can be observed after the economy has reached a certain threshold in per capita income[56], and that in the case of China this threshold will be reached within the next years. Therefore, growth rates that exceed the WACC do not necessarily mean that raising public debt now is a feasible option. A conservative approach expecting lower growth rates would indeed suggest the opposite.

The only curious case is Iceland, an advanced economy with a high growth rate between 2004 and 2009. In this case, assuming that Iceland will revert back to reaching high growth rates once it fully recovers from the Great Recession, public debt seems like a feasible option. However, as a result of the economic crisis Iceland was already forced to raise the national debt level. The public debt relative to GDP is currently at over 80%[57], which is a substantial increase from the debt level since the beginning of the millennium, during which it stayed between 20-40%. Before considering raising the debt any further, the effect of the recent raise should be awaited.

To sum up, evidence for dynamic inefficiency could be found for a few countries in the sample. At a first glance, this might suggest that overaccumulation is indeed a problem that has to be addressed in the form of public debt. Interestingly, this is not necessarily true. Even in the cases where a comparison of interest and growth rates would at this point indicate dynamic inefficiency, a policy encouraging higher debt levels is not advisable if a decline in growth rates is expected in the long run. Even in Homburg's (1991, 1992, 2014) land model the interest rate can fall short of the growth rate at times. Eventually, it will always be above the growth rate and ensure dynamic efficiency. The observation of seemingly inefficient economies thus does not invalidate his claim. The other categories will now be investigated to see what additional insights can be taken from them.

Most of the big economies in Europe as well as the United States and Japan can be found in category I. There is no emerging or developing economy among these countries, who demonstrate a striking similarity in their WACC and growth rate movements. The WACC are well above the growth rate over the entire period considered with only a few exceptions. The behavior of advanced economies is especially interesting because it is the closest estimation to a steady state that can be observed. Assuming that emerging market countries will follow a similar development and seeing that the countries in category II are clearly far from overaccumulation thus suggests that in the long run, inefficient allocations are unlikely.

[56] $US 17000 in 2005 constant international prices.
[57] Source: OECD.stat.org. Effective September 2014.

The fact that these economies behave so similarly strengthens this proposition. This finding is in favor of Homburg's (1991, 1992, 2014) land argument that rules out the possibility of inefficiency in the limit. It is also interesting to note that with the USA, Germany, and Japan, countries that have been feared to have accumulated too much capital by e.g. Summers (2014), von Weizsäcker (2014), and Geerolf (2013), respectively, show no indication of such behavior. Von Weizsäcker's (2014) reasoning is that public debt is necessary because the real rate of interest has become negative in the OECD countries + China, as has been discussed in Chapter 2.2.. He attributes this to a longer retirement period and resulting higher savings, a development inherent to the rich countries. Therefore, public debt in these countries is needed to absorb these excess savings. As has already been discussed, raising the public debt is only feasible if the economy is in a state of dynamic inefficiency. If one followed von Weizsäcker's (2014) reasoning, rich western countries would especially need to accumulate public debt, because rising pension entitlements play a major role in these economies. However, it is precisely these countries that the comparison of WACC and growth rates clearly identifies as efficient. Raising public debt would thus have a negative welfare effect instead of a positive one and reasonable policy implications would strongly discourage debt schemes. As von Weizsäcker's (2014) theory cannot easily be verified, while the efficiency analysis conducted in this thesis relies on real data, raising public debt does not seem to be a suitable option for the rich countries across the globe.

Category IV contains a mix of advanced and emerging economies. According to the IMF (2014), Hungary, Mexico, and Poland are categorized as emerging and developing economies, while the rest of the countries in this group belong to the advanced economies. Out of these, the Czech Republic was labeled to be an emerging economy in 2008 (IMF (2008)), similar to Estonia and Slovakia. The comparison of WACC data and growth rates confirms dynamic efficiency when looking at the rates on average. Yet, the WACC are not strictly greater than the growth rate over the entire horizon, so that looking at shorter periods of time, one might suspect these countries to be dynamically inefficient. This stresses the importance of looking at the data over the longest time frame possible. The longer the period under examination, the more reliable the results are in representing the actual state of the economy. With the exception of Mexico and Israel, the WACC exceeded the growth rate over the last years since the crash in all countries of category IV. There is no trend for the future development of the growth rates. Most countries have exhibited high growth rates prior to the crash despite being advanced economies. It remains to be seen whether or not they return to these levels, similar to the case of Iceland.

Nevertheless, the data suggests that these countries are dynamically efficient and that therefore, public debt is not a policy that should be pursued. Additionally, these countries show that even though the growth rate can exceed the interest rate over several periods, overall efficiency is ensured.

One country out of this group that requires a closer look is Greece. In 2011:II, the WACC skyrocket to a level of almost 40% and instantly fall to the lowest level observed between 2000 and 2014 (4.28%). A look at the WACC data shows that out of the 60 companies considered, 15 firms exhibit WACC over 15% in that half-year. Some of these are higher than 100%, one company reaches almost 350% (Diagnostic & Therapeutic Center of Athens) and another over 390% (Elgeka SA). These 15 companies come from very different backgrounds and the WACC immediately drop to low levels after the surge. There is no apparent explanation why these values are so unreasonably high. Whether or not this behavior is related to the economic crisis or another development is left to another investigation with a stronger focus on the Greek economy.

The last group to be discussed is category III. For these countries, the WACC suggest dynamic efficiency, while the interest rates point to inefficiency. If it were not for this distinction, all the countries in this group would be counted to category IV and the interpretation of the findings would be accordingly. Similarly, it is very possible that if interest rate data on the countries in category IV is obtained, it might suggest inefficient growth for these economies. However, as was already discussed, the WACC are a better estimate of the cost of capital for firms and therefore the relevant data for the assessment. The analysis thus implies that dynamic efficiency can be assumed for these countries, as well as for the countries in category II and IV.

More importantly, this result shows that the pre-test that was suggested at the beginning of the last chapter has to be taken with caution. In the case of Austria, Belgium, France, Germany, Italy, the Netherlands, Portugal, the US, and the EU12 aggregate, the pre-test gives the same indication as the WACC. This result is in favor of using the pre-test. To be sure, it cannot be used to definitively determine whether or not an economy is efficient, because it might lead to the wrong results, as can be seen from the countries in category III. Nevertheless, it should not be rejected completely. One of the conditions for the test to work was that the WACC actually always exceed the interest rates on loans by non-financial corporations.

This is consistent with the data, for the WACC almost always exceed the interest rate over the entire horizon, and usually by a visible margin. The only exceptions to this are Greece in 2012/2013, Slovakia in 2014, and the USA in 2000, where the interest rate is slightly greater than the WACC.

Considering that the interest rate data is more readily available than the WACC data, using the interest rate for a first assessment of the efficiency dynamics of an economy proves to be quite useful. Only when dynamic inefficiency is suggested by the data, a further investigation based on WACC data is necessary. If the interest rates point to efficient behavior, so will the WACC. This test is quickly undertaken and able to save researchers a lot of time if they are only interested in potentially inefficient countries. On the other hand, if the aim is to examine the behavior of an economy more closely, a direct look at the WACC data constitutes a better choice, as some movements that can be observed using WACC data remain hidden when interest rates are used. An example of this will now be provided.

The difference between the WACC and the growth rate increased drastically for almost all countries during 2009, reflecting the Great Recession. Homburg (2014) already found this to be true using interest rates for non-financial corporations for the euroarea and Moody's Aaa bond yields for the US. He further explains that this led to a large number of private and sovereign defaults as a result of tighter budget constraints. Looking at the more accurate WACC data instead of the interest rate not only confirms his result, but paints an even clearer picture of what happened afterward. For the aggregate EU12, Homburg's graph shows that the interest rate dropped during the recession and then stayed relatively constant. The surge in the growth rate following the Great Recession then reduced the gap very fast. For the US, the growth rate even exceeded the interest rate for a short time after 2010. Looking at the European countries in category II one by one instead of the aggregate, the growth rate exceeded the interest rate for several countries in 2010 and sometimes even in 2011.

According to the same argument used during the recession, one might think that this opposite movement should decrease pressure on the budget somewhat. However, after the crisis this was not observed. As Summers (2013, 55:30 h) points out, one would normally expect higher growth rates than usual after a recession due to the GDP trying to catch up to its potential. And indeed, growth rates rose again for a short time after the crisis, but they did not even exceed the level prior to the crisis and then began to decline again slightly. Looking at the WACC gives one possible explanation. For most countries, the WACC rose together with the growth rate or a little later.

This was a decrease from the gap observed in 2009, but it was still an even higher differential than before the Great Recession for most countries, continuing to exert pressure on the debt service. During the second recession wave that started in most countries after 2010 the gap rose again, tightening budget constraints once more. This may possibly explain why most of these countries still struggle from the recession several years after the crash of 2009.

A reason for the increase in the WACC could stem from an increase in perceived risk, mirrored in higher risk premia. This would also explain why the upward movement lagged behind a couple periods, as it always takes time for the markets to adjust to such changes. A more thorough explanation of why the WACC rose the way they did will need to be left to another analysis with a stronger focus on the nature of the WACC.

To sum up the results of the assessment, a short comparison with other examinations already mentioned in this thesis is useful. The big advantage of this method of assessing dynamic efficiency is that unlike the criterion used by Abel et al. (1989) and Geerolf (2013) that needs to be positive in all periods, it allows the interest rate to fall short of the growth rate for some periods without jeopardizing dynamic efficiency. Due to the strong conditions that need to be fulfilled using the dividend criterion by Abel et al. (1989), Geerolf's (2013) results after updating the data for land data and entrepreneurial income showed that inefficiency could not be ruled out for a lot of the countries also covered in this analysis. For the countries considered by Abel et al. (1989) in their original paper, this was in fact a change for the worse, as they had attested dynamic efficiency for these countries. The comparison of WACC and growth rates conducted in this analysis therefore reestablishes Abel et al.'s (1989) result, though with significantly lower requirements. Using the dividend criterion, Geerolf's (2013) results remain unsatisfactory, because overaccumulation cannot be rejected for almost all countries under consideration. This applies to Belgium, France, Germany, Hungary, Italy, Norway, Sweden, Switzerland, UK, and the USA. The analysis of WACC and growth rate data is able to give a definite answer to the question of dynamic efficiency: None of these economies are in danger of overaccumulation. In direct contrast to the results of this analysis, Geerolf (2013, p. 2) finds Japan and South Korea to be "unambiguously inefficient" and claims that Australia and Canada are prone to overaccumulation. A comparison of WACC and growth data yields no support for this judgment, especially concerning Japan, the country showing probably the clearest case of dynamic efficiency among all countries considered in this thesis. Instead, the analysis even finds support for the argument that dynamic inefficiency is a phenomenon that will unlikely persist in the long run.

However, possible objections can be made to the results of this analysis with respect to the reliability of the data used. This issue will be addressed next.

4.2. Limitations and Reliability

The criterion used in this assessment relies on the behavior of interest and growth rates in the limit. Due to a lack of perfect foresight in reality, any analysis conducted according to this criterion is not able to provide a definitive answer to the question of dynamic efficiency for any country, so the results should be assessed conservatively. Still, they are a good indicator of the current state of the different economies, and if one assumes that the rates are ergodic, the results obtained from the analysis should also hold in general. Nevertheless, the time horizon considered is rather short, covering only the years from 2000-2014. In order to reassess and possibly strengthen the findings, another analysis covering 30-40 years or even longer would be desirable. Unfortunately, this was not possible at this point as the WACC data by Bloomberg are not available before 2000 and other databases do not collect the data to this extent yet. A more extensive analysis thus has to be left for future research.

The stock markets used for the collection of the WACC differ in size, reaching from 7 companies (Slovakia) to over 1000 (USA). The size of the stock market is not correlated to the size of the economy per se. For Finland and Germany, two very different countries, 130 companies are used, while for France, which is smaller than Germany but bigger than Finland, only 40 companies are taken into consideration. South Korea's WACC are calculated using over 750 companies, while Canada – a country with a similar PPP-GDP in 2000 according to the Penn World Tables – only uses 251 companies. The numbers for all stock markets can be taken from Table 2. It could be argued that due to the asymmetric treatment of the different countries, the WACC data calculated from the individual companies are more reliable for countries for which more companies were used. Another problem that adds to this is that values are missing for many years and many companies across all countries. This weighs especially hard on those countries that have a smaller pool of companies to begin with. However, these two issues affect the reliability of the data in different ways.

The difference in the size of the stock market intuitively leads one to assume that the data for e.g. the Netherlands with 25 companies is not as good an indicator as the data for the USA with over 1000 values.

This stems from the common rule that the larger the sample size, the better the estimate of the value in question. It is generally correct that a larger sample size enhances the accuracy of the approximation. This is especially crucial for random variables. Essentially, the WACC of the companies listed in the stock market are not random, but rather express a systematic function, meaning that the marginal benefit from more companies should decrease faster. Additionally, there has already been a selection process of data by choosing to only consider data from certain stock markets. A high diversification of industries within the stock markets adds to the robustness of the data against shocks to just one branch of the economy. The fact that the WACC data is on average quite similar for most countries independent of the sample size supports the view that the different sizes of the stock markets do not invalidate the data. As an example, even though the sample size of the Netherlands and the USA differs considerably, the average WACC are not that different at 7.96% and 8.83%, respectively. This does in no way mean that the sample size is irrelevant and that the values from 7 companies in Slovakia are as accurate as the numbers from 762 companies in South Korea. How many companies are needed to get the best estimate is unclear. One might not need 1000 companies for each country, and for many countries this amount of data would be difficult to obtain anyhow. On the other hand, too few will most likely not be enough to reach the diversification needed to represent the economy as a whole. Therefore, the data for countries with a small stock market should be taken with caution, as should the insights from the analysis.

To summarize, the fact that for some countries the WACC are determined from a smaller sample size than for others does not overthrow the results as long as the number of companies is sufficiently large, meaning that they adequately represent the economy. The striking similarity of the WACC across the countries underpins this assumption.

In contrast to varying sample size, the missing values truly pose a problem for the analysis, because they reduce the sample size further, which leads the numbers of values to fall to insufficient levels for some countries. For all countries, the number of companies reporting the WACC increases over time. For the countries with smaller stock markets, almost all companies are assigned WACC values for the last couple periods. Generally, the WACC data are more complete for advanced economies than for the emerging countries.

Some of the estimations of the WACC are derived from just very few companies; in extreme cases they even reflect just one company for several periods. This is for example the case for Slovakia for the first two and a half years and Iceland for the first year and a half. By the end of 2013, only 10 out of the 14 companies in Iceland report WACC data.

For Slovakia, all seven companies report WACC for the past four years. However, this number is still very low. Therefore, the estimates for the first periods might not reflect the cost of capital as well for the country as a whole. The results for these two countries – which were both found to display signs of overaccumulation – could therefore not be accurate. For some of the countries, the number of companies reporting the WACC is limited over the whole period considered, so the estimates for these countries are especially prone to distortion. These countries are Czech Republic, Estonia, Hungary, Iceland, Luxembourg, Slovakia, and Slovenia. For most of the other countries with data deficiencies, the number of available WACC data reaches a critical value after a few years.[58] Therefore, the exact shape of the WACC data is not always best represented by the stock market approximation and the results for these countries should be assessed cautiously. A more accurate collection of the WACC data for these countries is left for further research when more complete datasets are available.

One last remark towards the reliability of the data concerns the fact that Bloomberg estimates the WACC themselves, using risk premia and betas that are calculated by Bloomberg. Any bias in the Bloomberg data automatically translates into distortions in the analysis using this data. Still, since Bloomberg is the only database supplying WACC data on the scale needed for the analysis of this research, this compromise was necessary. This does not mean that the data are actually distorted. Sharfman and Fernando (2008) used several calculations of the WACC in their analysis, among them the Bloomberg estimate, and did not find significant differences in the implications from using the various WACC measures. Hence, there is no reason to believe why the implications drawn from the Bloomberg WACC should vary from WACC calculations obtained using other standard risk premia and beta values.

[58] In the following list, the year in parenthesis corresponds to the year when the WACC were determined from at least 20 companies. Countries that are not mention in this list are calculated from more than 20 companies over the entire horizon: Austria (2006), Belgium (2010), Denmark (2006), France (2001), Greece (2001), Ireland (2006), New Zealand (2002), Netherlands (2004), Norway (2005), Poland (2010), Portugal (2008), Spain (2001), Switzerland (2002), China (2002). The critical value of 20 was chosen owing to the fact that the major stock markets for many countries (e.g. Austria, Belgium, and Switzerland) only encompass 20 companies. As was already mentioned, the similarity of the WACC data for these countries suggests that they are a good estimate for the national level, even if they are from just 20 companies. Though a higher number of companies would increase the accuracy of the estimate, 20 companies seem to be sufficient for a first assessment.

CONCLUDING REMARKS AND OUTLOOK

"Public spending is the easiest of all recovery methods, and therein lies its danger."
Alvin Hansen, 1939

Are major economies overaccumulating capital, enabling a "free lunch"? This thesis investigated this question and for most countries, the answer seems to be no. In order to address this problem, an overview of the theoretical background on dynamic inefficiency as well as a criterion to assess it was given. The possibility of Ponzi schemes in overaccumulating economies was dealt with and an extension to the Diamond model by Homburg (1991, 1992, 2014) that includes land which renders overaccumulation impossible was presented. The second chapter described a sample of empirical investigations conducted so far and analyzed the different criteria and interest rates used with respect to applicability and reliability. From these results, a new criterion was derived that is based on a comparison of the WACC as a proxy for the cost of capital and the growth rate of nations. The WACC had to be calculated from a large sample of firm data within each country to obtain a national estimate of the WACC. In order to get as extensive an assessment as possible, the analysis was conducted for all OECD countries plus China. In addition, the feasibility of a test with the more readily available interest rates on loans for non-financial corporations was considered and found to be practical, though the results have to be considered carefully, as they do not always reach the same result as the WACC.

For future research, it remains to be hoped that data on the WACC will continue to be collected extensively by Bloomberg or other databases, so that another analysis similar to the one presented here can be conducted later on. A less accurate but still possible assessment at this point would be to use the interest data on loans to non-financial corporations over the past decades. Unfortunately, this data is also not attainable for all countries reaching as far back as necessary[59] to cover several decades. Nevertheless, for the countries where these values are available, an analysis could complement the results deduced here and provide further insights. However, in conducting such an analysis it is important to note that if these rates are used and a country is found to be inefficient, this does not necessarily mean that this would also apply using the WACC measure. If, on the other hand, the criterion points to efficiency, then this will a fortiori hold using WACC data.

[59] For example, the German Bundesbank has published a „Zinsstatistik" (Interest Rate Statistics) that collects interest rates from 06.1967-06.2003, after which it was replaced by the MFI statistics. However, the interest rates on loans to non-financial corporations and entrepreneurs only goes back to November 1996, yielding little additional insights to the analysis conducted with the WACC starting in 2000.

In summary, the evidence from this analysis suggests that the hypothesis of major economies being able to raise public debt at no cost is unfounded. With the exception of Chile, Estonia, Slovakia, Turkey, and Iceland, dynamic efficiency can be confirmed for all OECD economies, while China also displays symptoms of dynamic inefficiency. Among the advanced and major economies of the world, a change to a dynamically inefficient growth path seems unlikely. As these countries best approximate steady state behavior, the emerging countries can largely be expected to follow a similar growth pattern. A result of this behavior would be lowered growth rates, while the WACC seem to not be affected by the development stage of a country as much. This would in turn imply that all emerging economies will eventually escape the stage in which growth rates are higher than the cost of capital. Due to the fact that only the eventual behavior of an economy matters in the assessment of dynamic efficiency, this supports the view that a representative competitive economy will always converge to an efficient growth path, including the economies that exhibit signs of overaccumulation at the moment. This result endorses the existence of a mechanism such as described by Homburg (1991, 1992, 2014) that prevents economies from accumulation too much capital.

The findings of this analysis strongly oppose the view proposed by Summers (2013, 2014) and von Weizsäcker (2014) that countries with low interest rates should accumulate more debt. A higher debt in an efficiently functioning economy can never increase welfare, but only strain the economy by having to serve the debt later on. Thus, the possibility of a “free lunch” for countries like the USA or Germany seems like a far-fetched dream in the light of a comparison of interest and growth rates. Granted, public spending can stimulate the economy during a time of recession, and during a time when interest rates on government debt are low, it is a cheap option. Nevertheless, Hansen (1939) is right in pointing out the limits of such tempting measures, because a higher debt level can easily burden the economy once interest rates begin to rise again. The economies currently profiting from such low rates should therefore not pursue a strategy of raising public debt levels, but rather utilize them in the consolidation of the national finances.

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APPENDIX

1. Series Keys for the time series for interest rates

Source: ECB Statistical Data Warehouse at http://sdw.ecb.europa.eu

Country	Series Key	Data Availability
Austria	MIR.M.AT.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014
Belgium	MIR.M.BE.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014
Estonia	MIR.M.EE.B.A20.A.R.A.2240.EUR.O	01.2008 – 05.2014
Euro area[60]	MIR.M.U2.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014
Finland	MIR.M.FI.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014
France	MIR.M.FR.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014
Germany	MIR.M.DE.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014
Greece	MIR.M.GR.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014
Ireland	MIR.M.IE.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014
Italy	MIR.M.IT.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014
Luxembourg	MIR.M.LU.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014
Netherlands	MIR.M.NL.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014
Portugal	MIR.M.PT.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014
Slovakia	MIR.M.SK.B.A20.A.R.A.2240.EUR.O	01.2006 – 05.2014
Slovenia	MIR.M.SI.B.A20.A.R.A.2240.EUR.O	01.2007 – 05.2014
Spain	MIR.M.ES.B.A20.A.R.A.2240.EUR.O	01.2003 – 05.2014

2. Empirical Comparison of WACC, Growth Rates, and Interest Rates for all OECD Countries, China, EU12, EU17, and OECD+China

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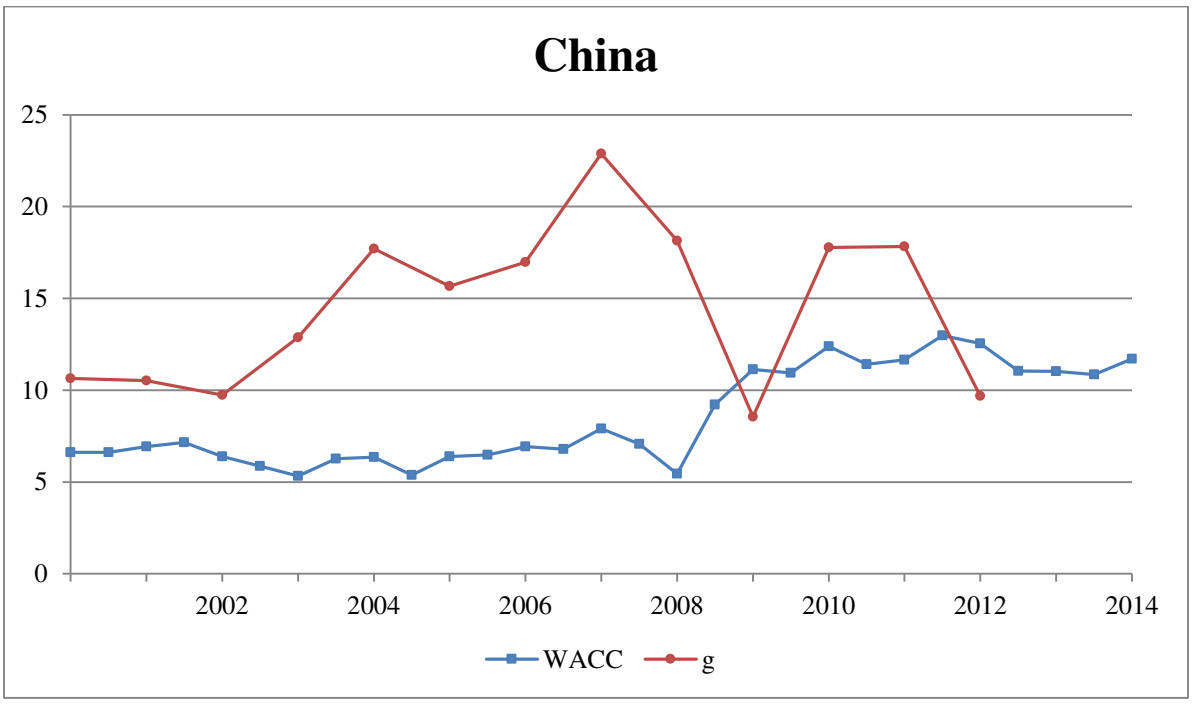
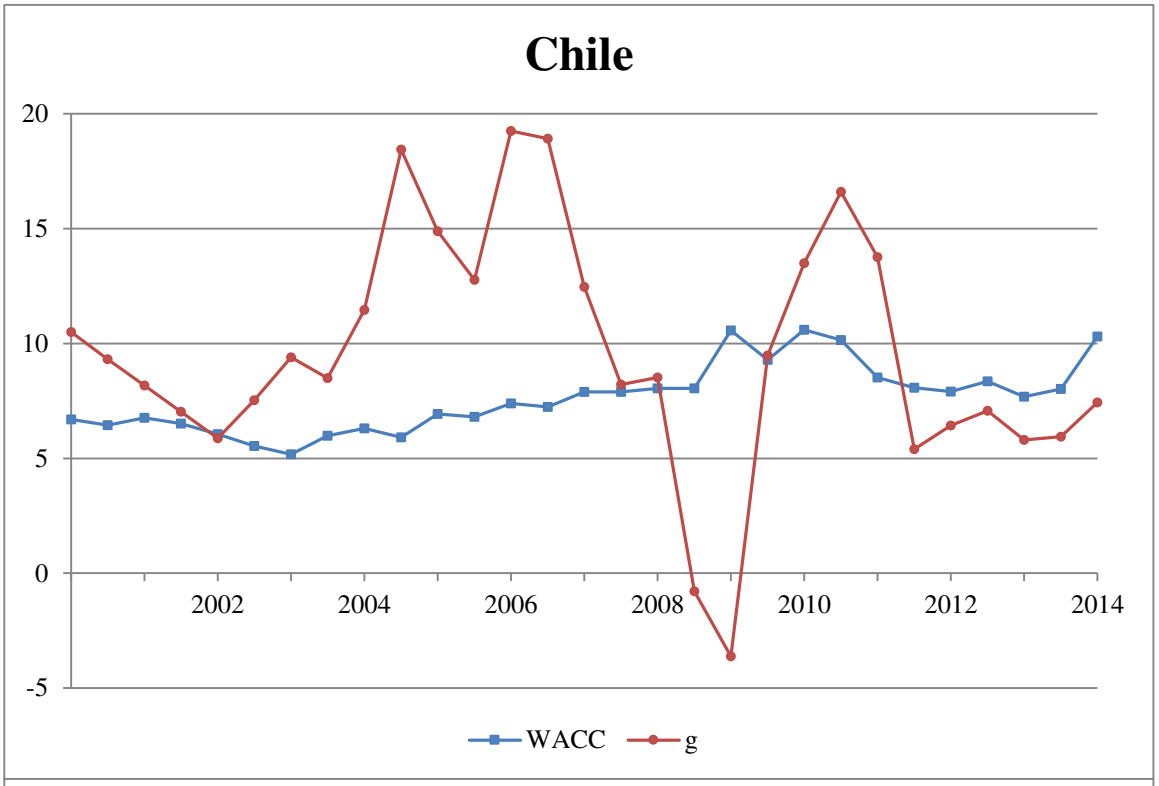


[60] Changing composition.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2012
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WACC
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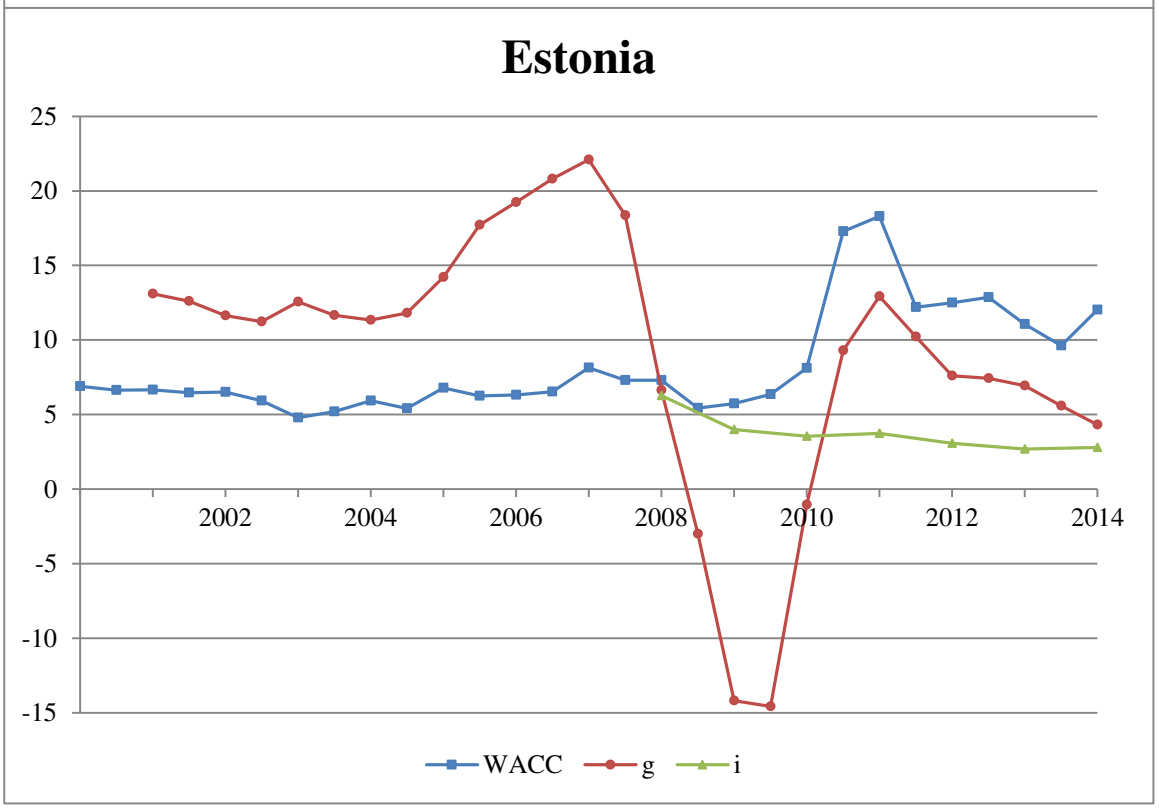
Estonia
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2002
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WACC
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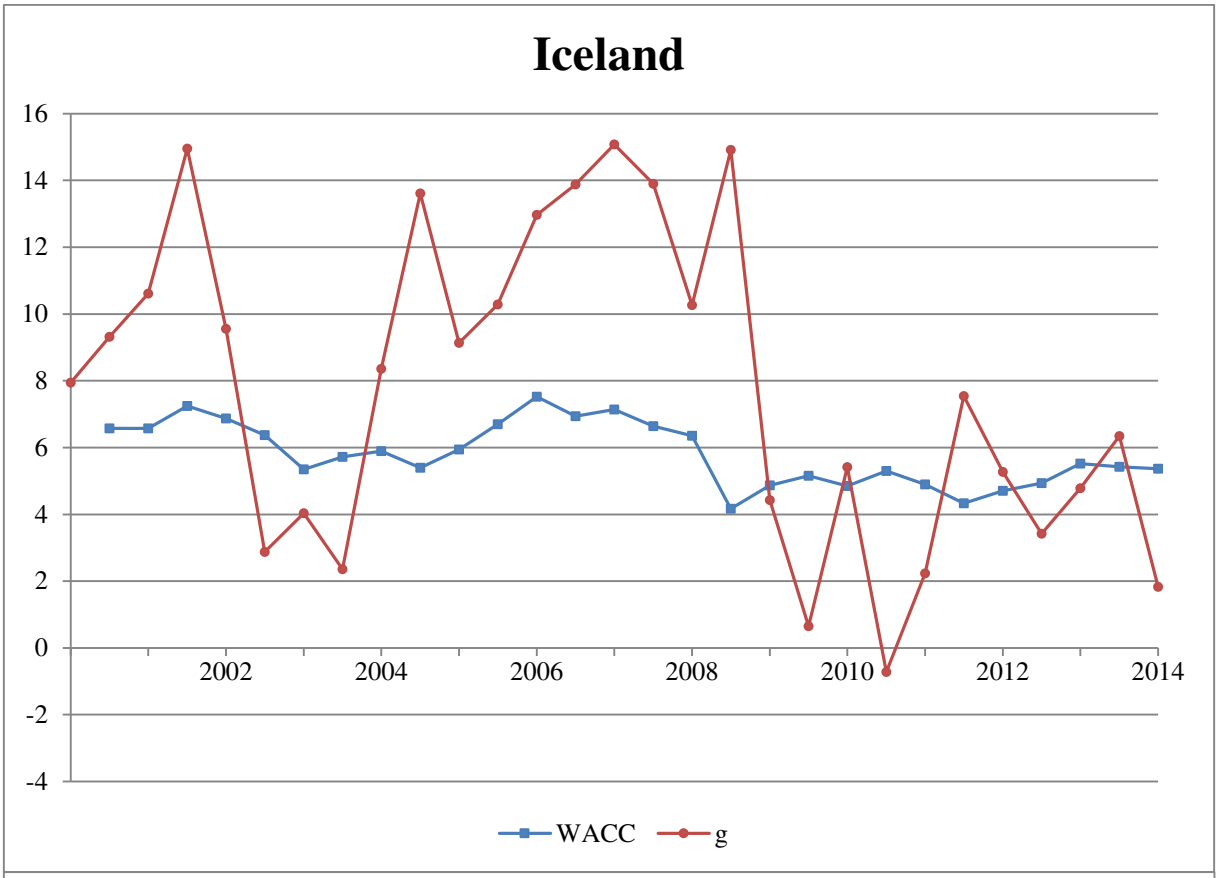
i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6
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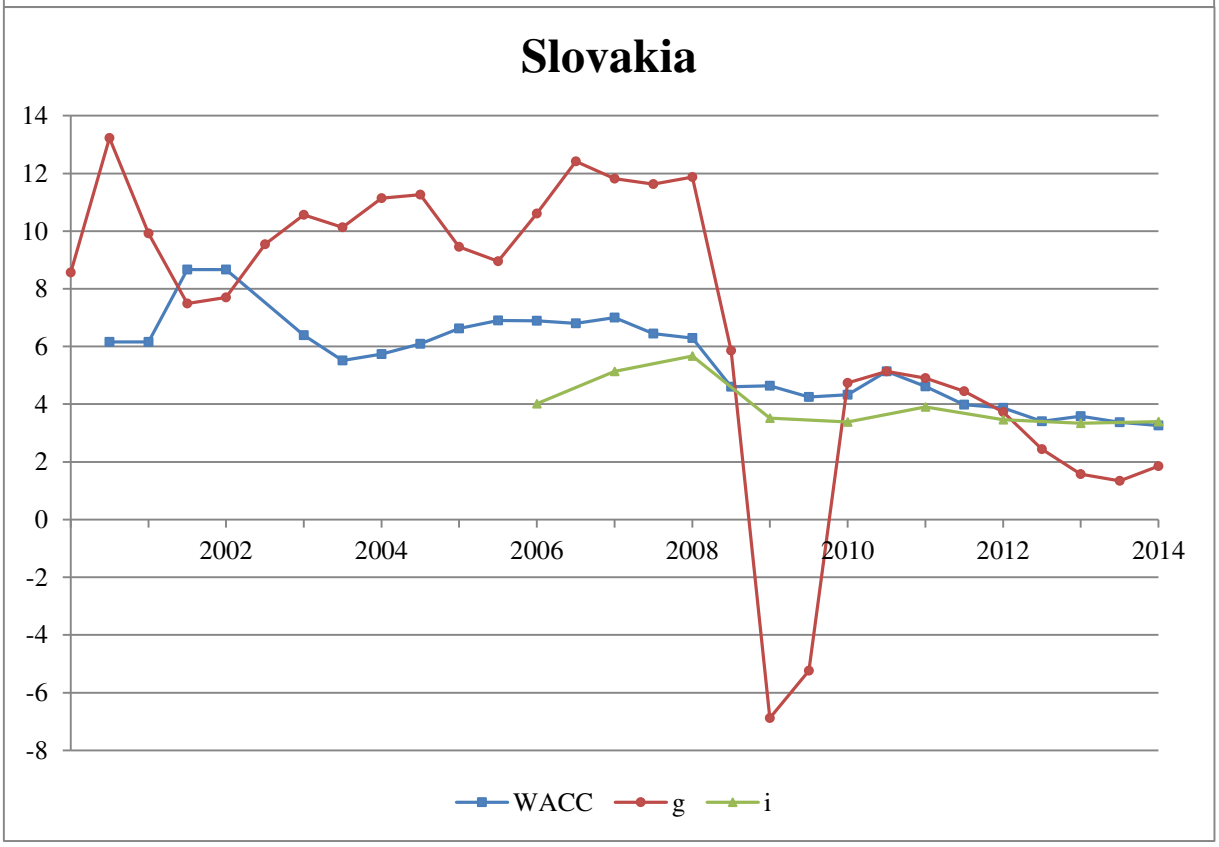
2002
2004
2006
2008
2010
2012
2014
WACC
g


Slovakia
14
12
10
8
6
4
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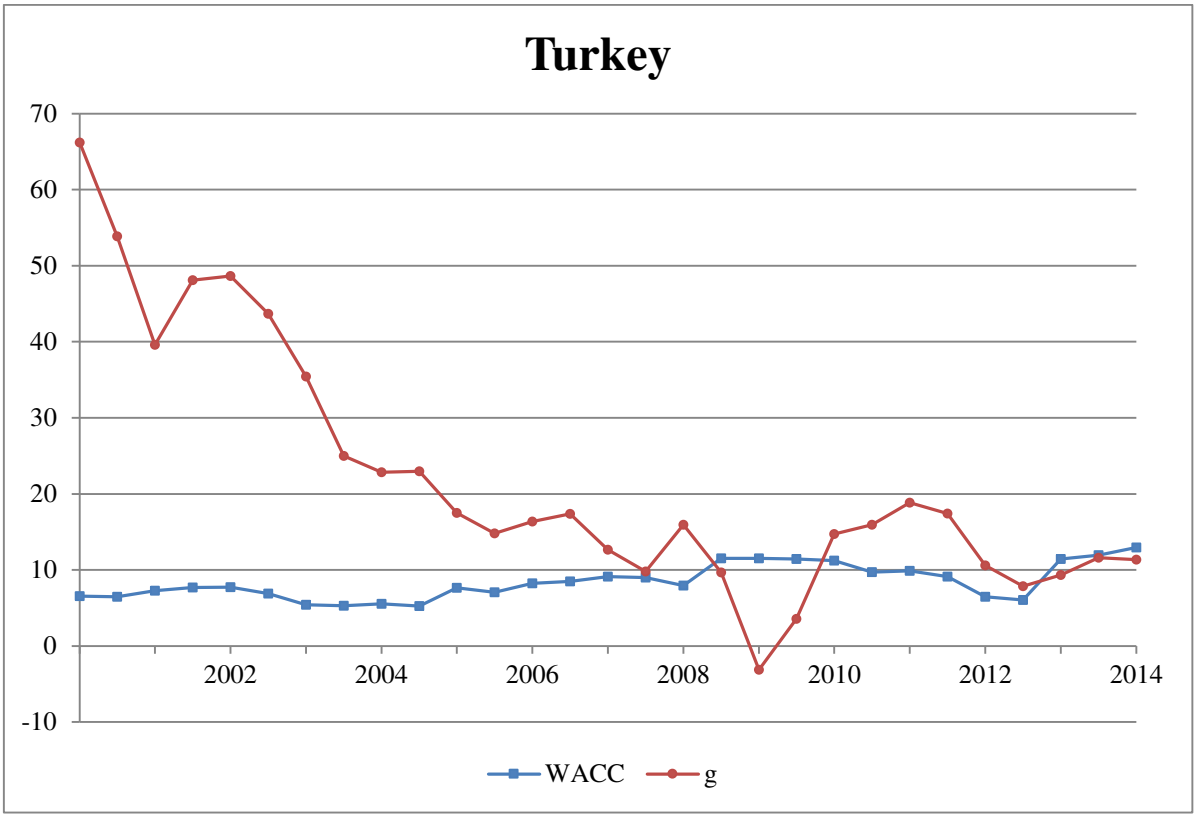
0
-2
-4
-6
-8
2002
2004
2006
2008
2010
2012
2014
WACC
g
i


Turkey
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2002
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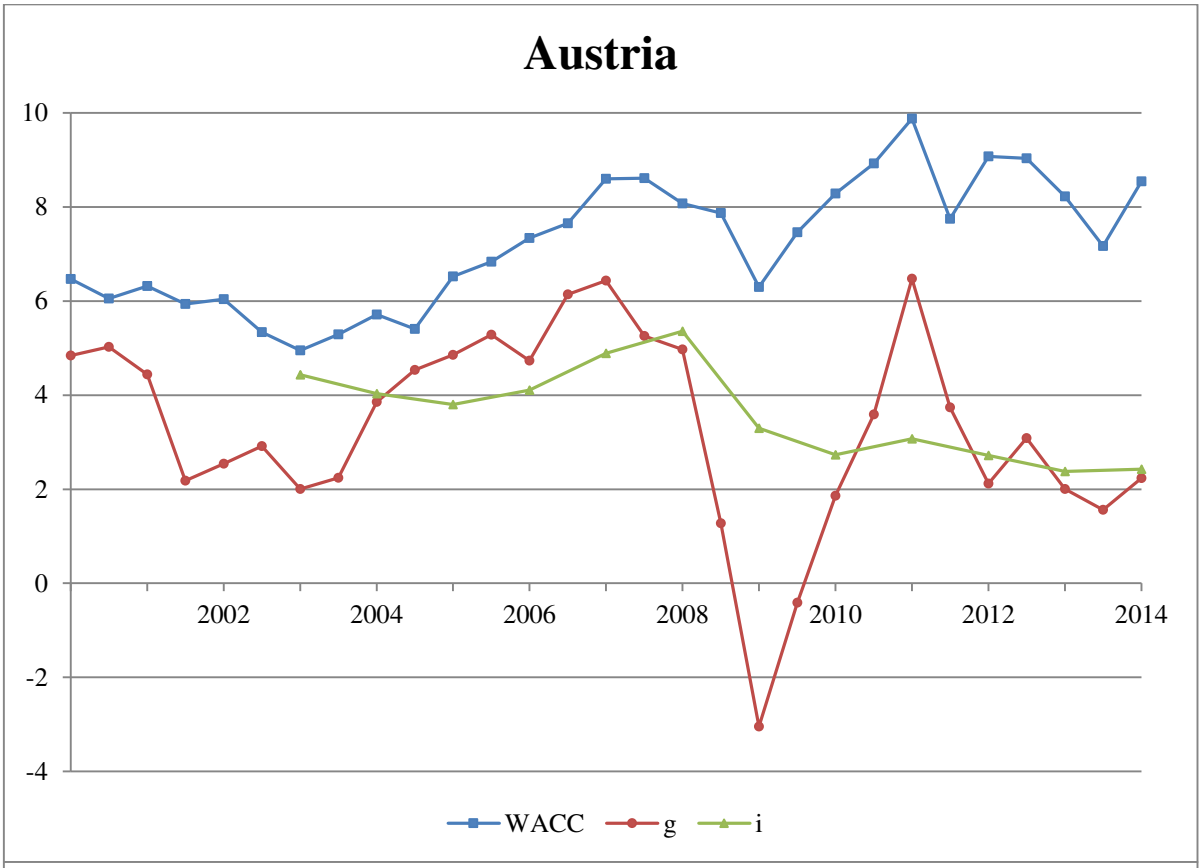
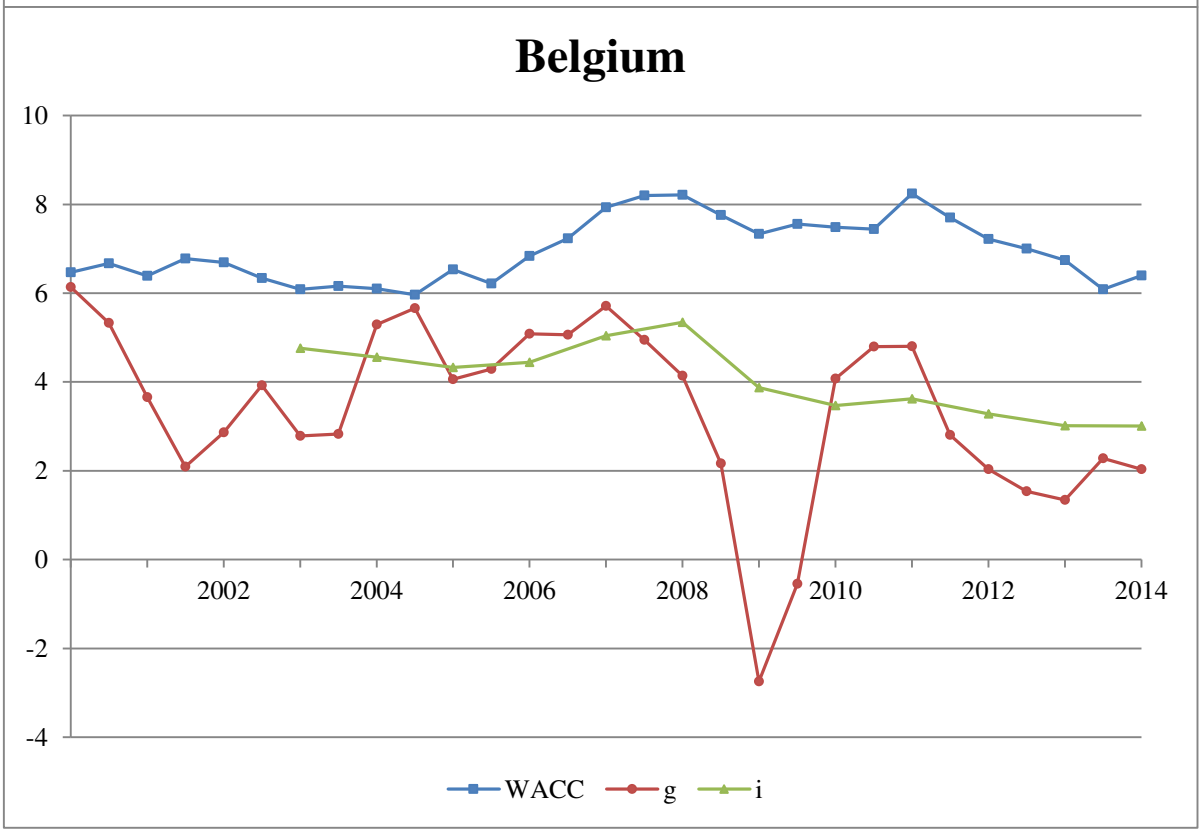
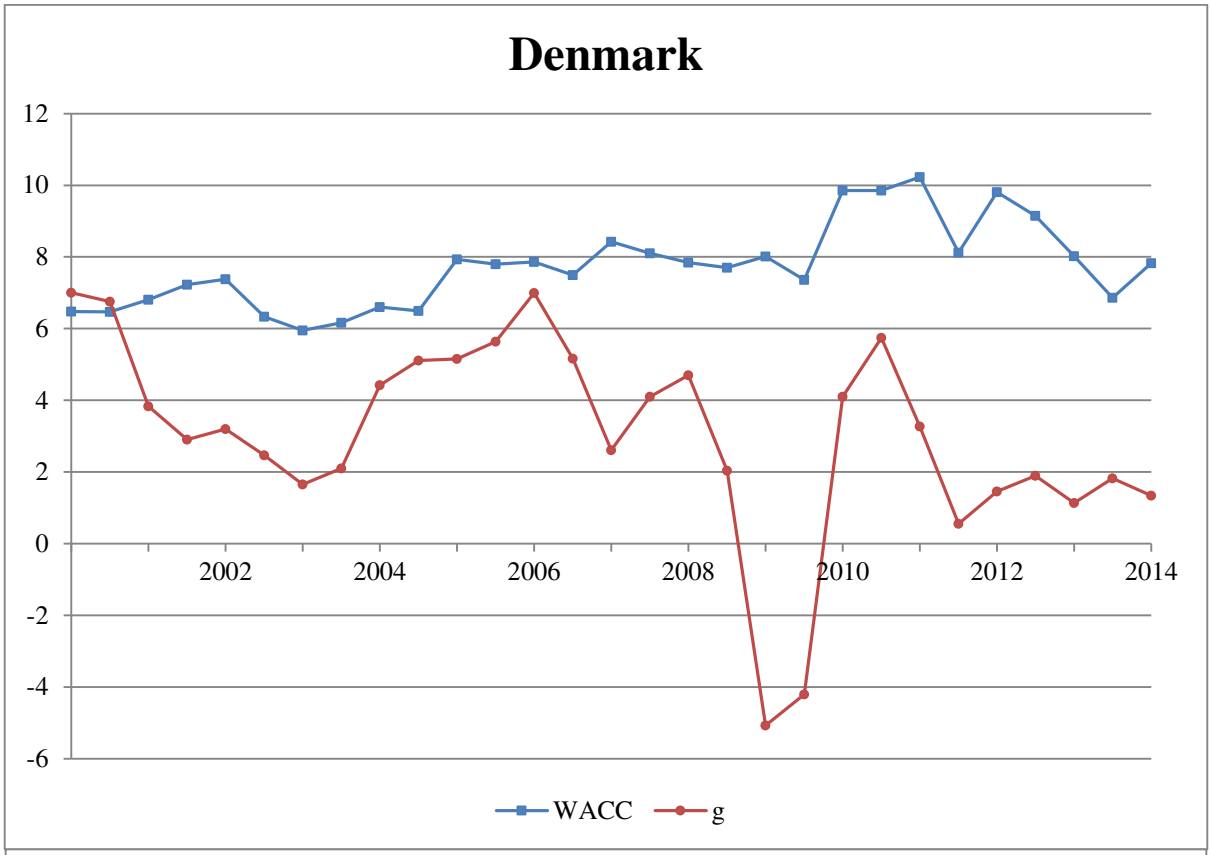
2006
2008
2010
2012
2014
WACC
g

2.2. Category II






Denmark
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-6
2002
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2010
2012
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WACC
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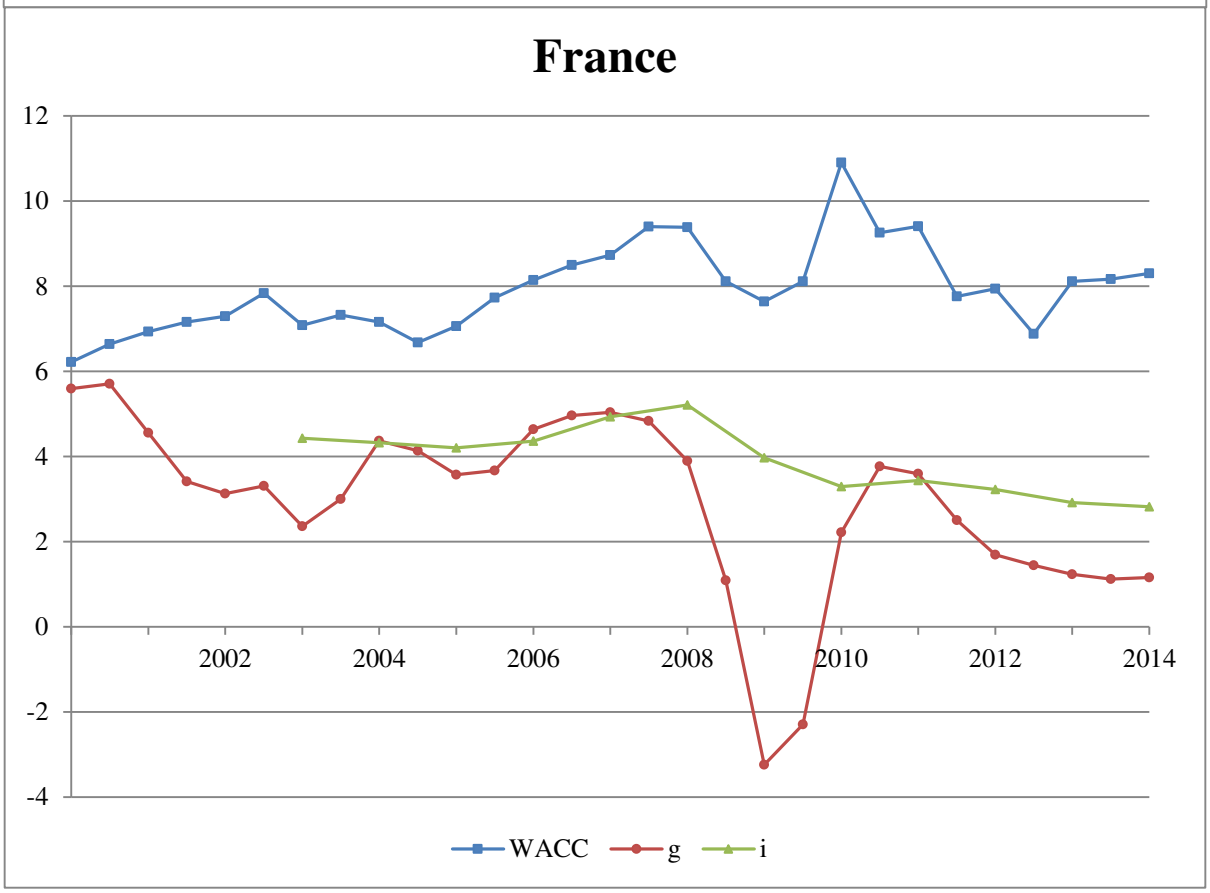
France
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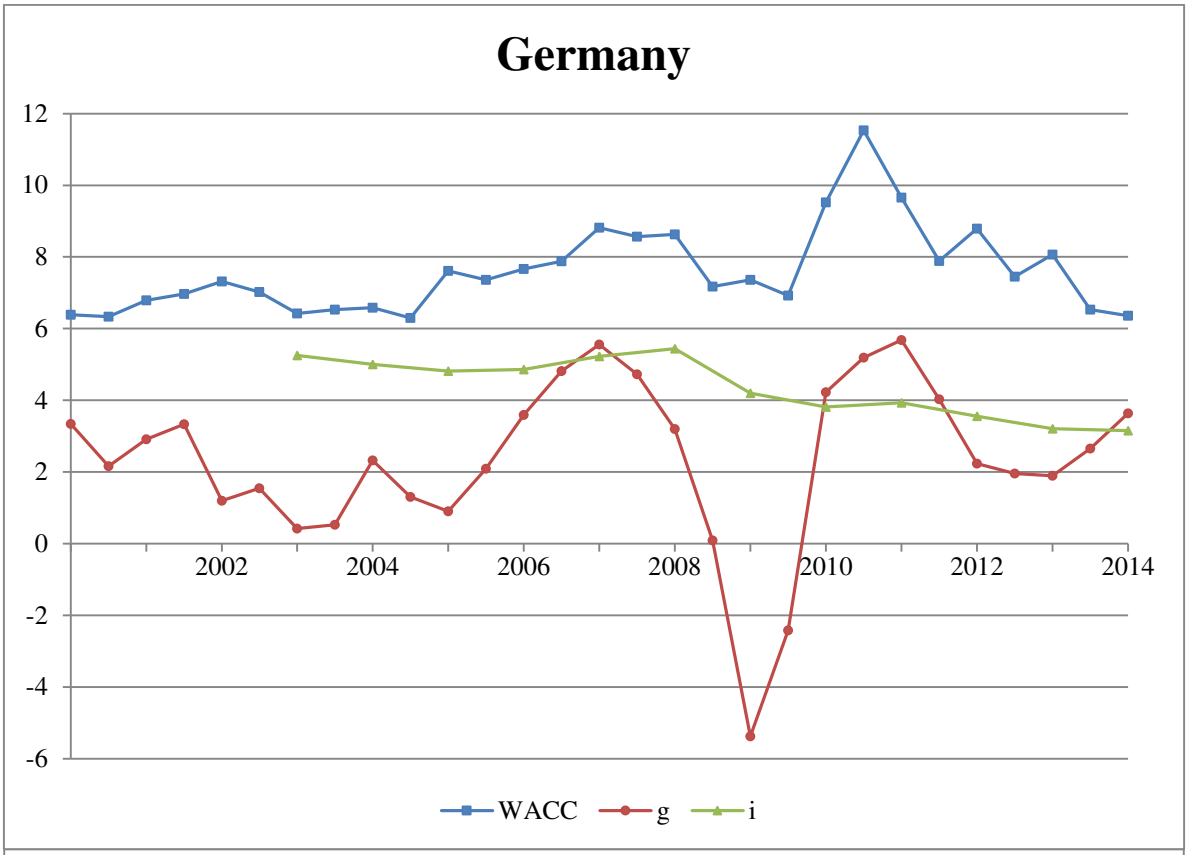
Germany
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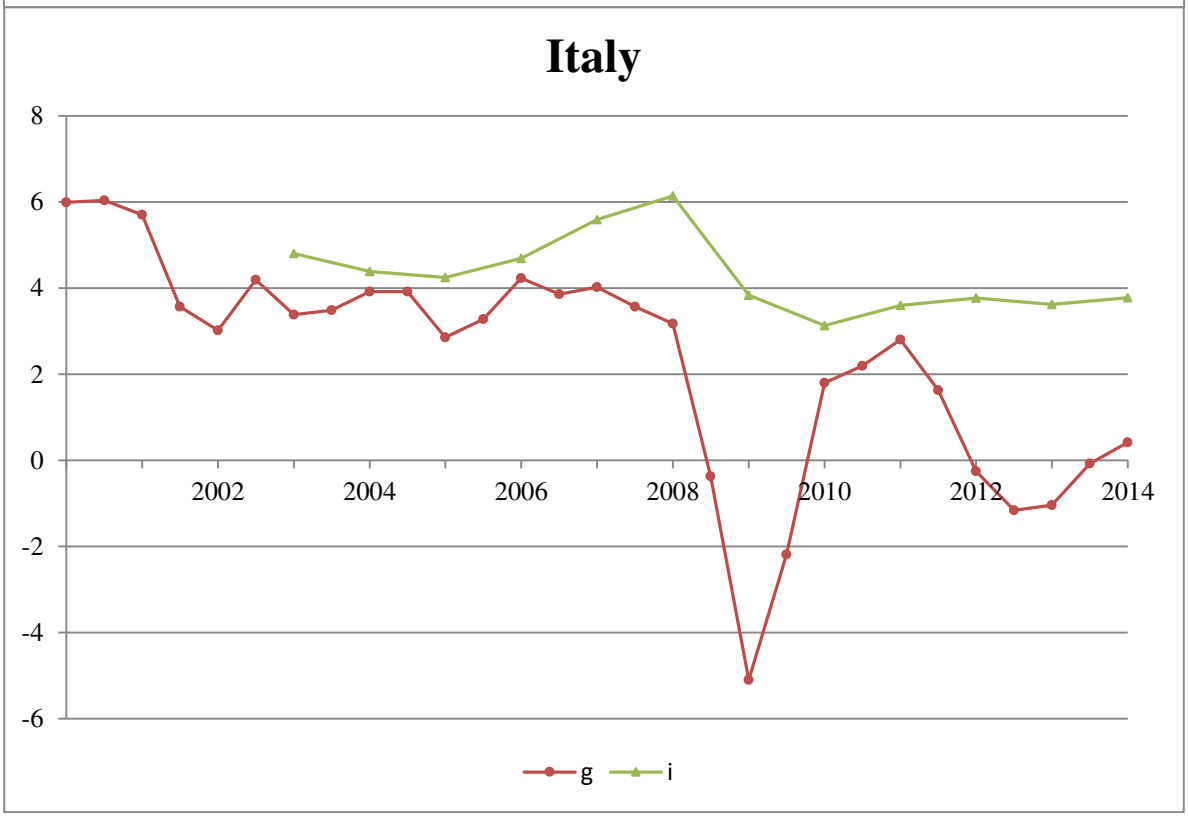
Italy
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2002
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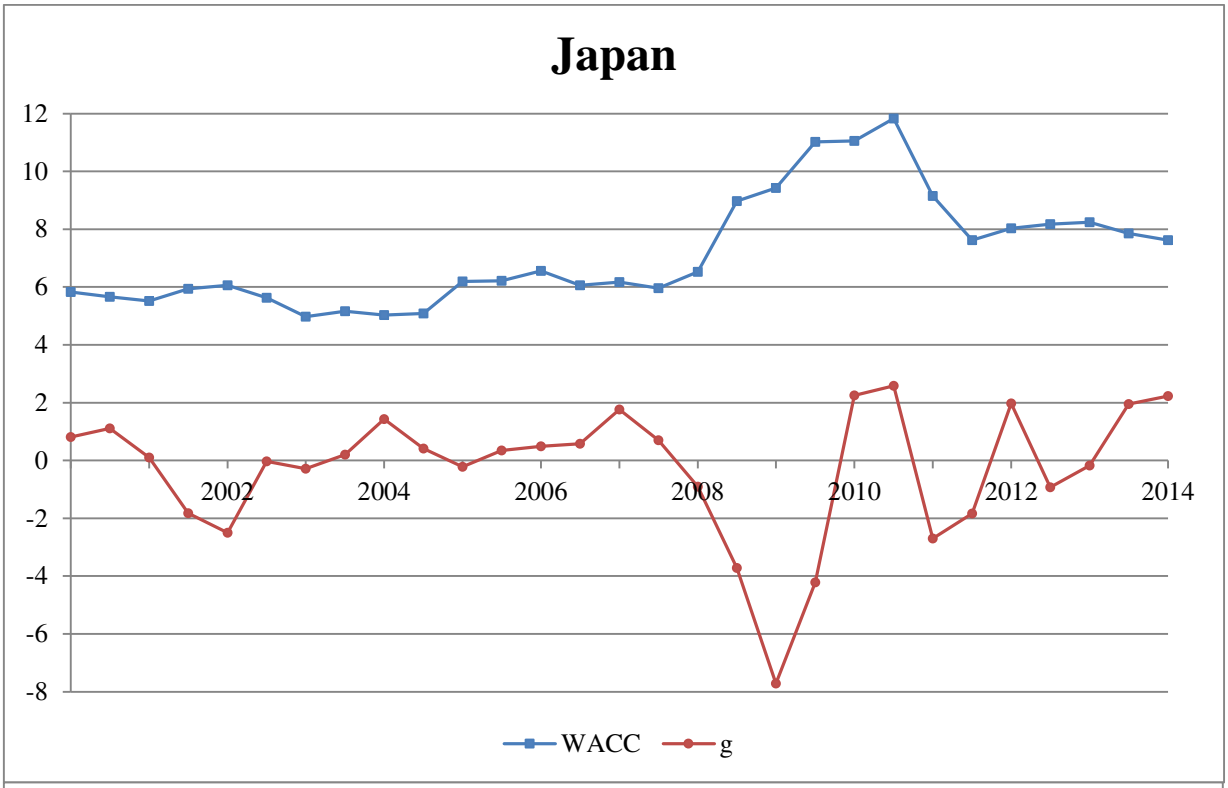
Japan
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2012
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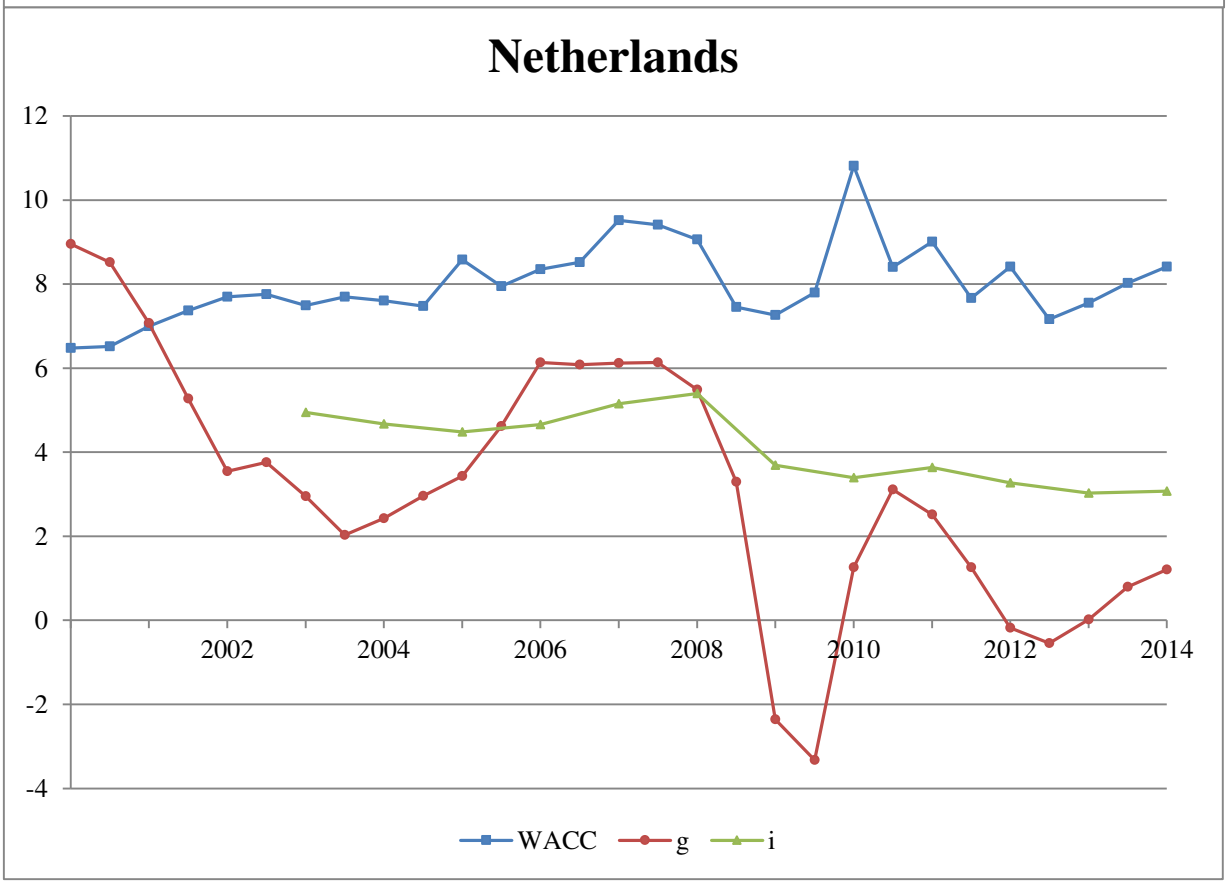
Netherlands
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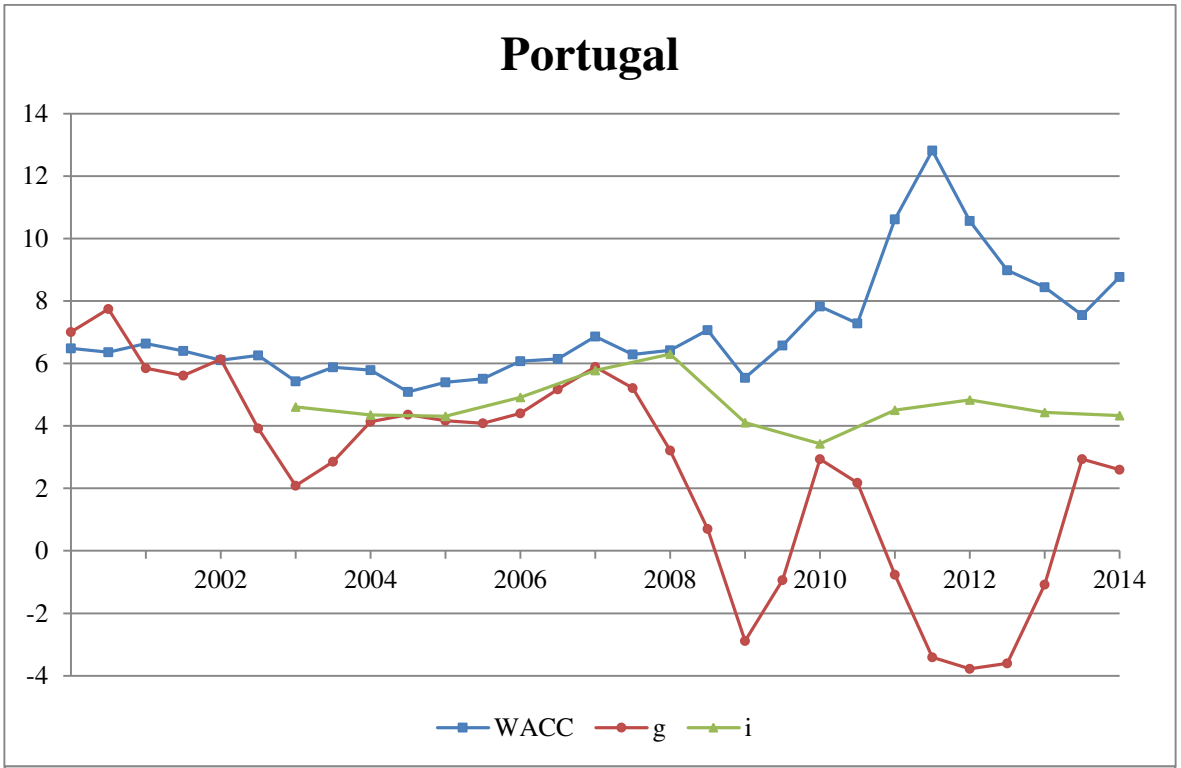
Portugal
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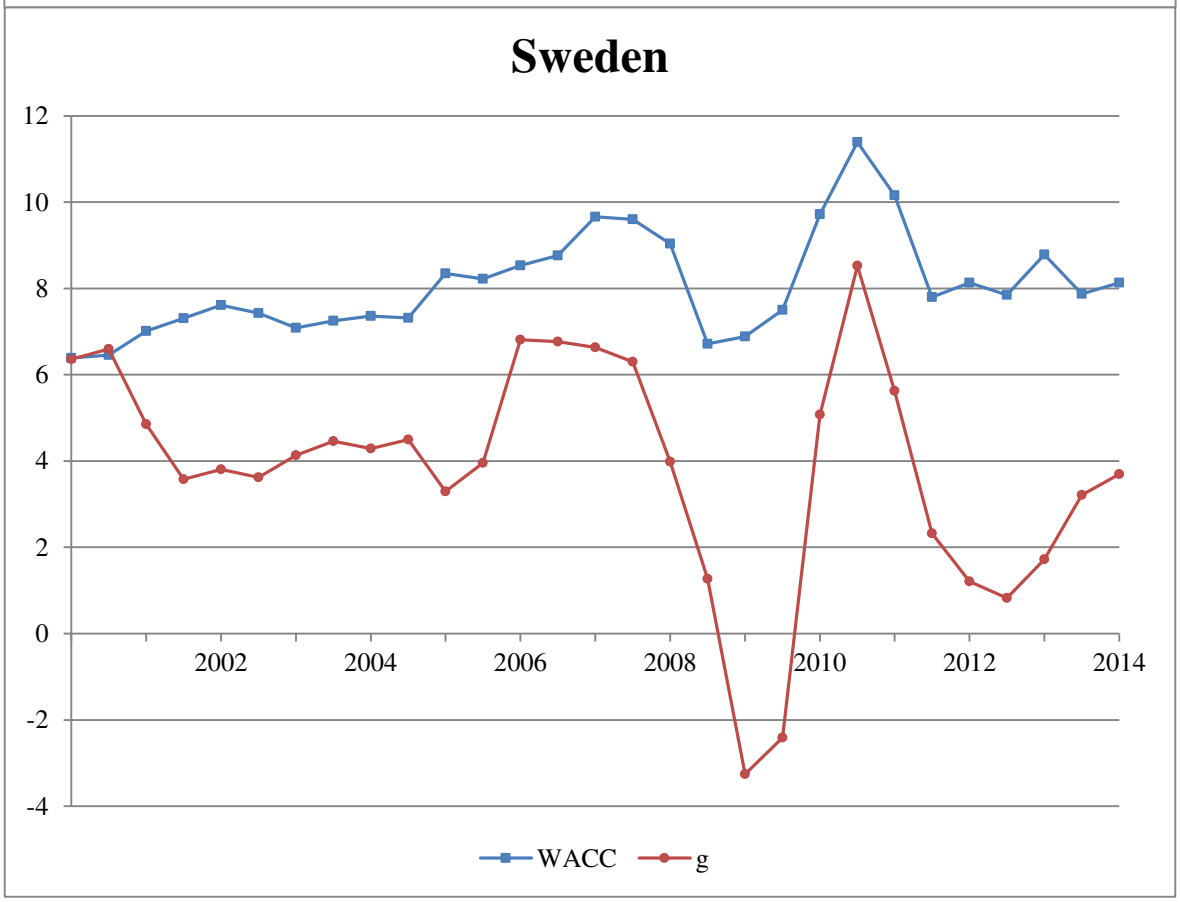
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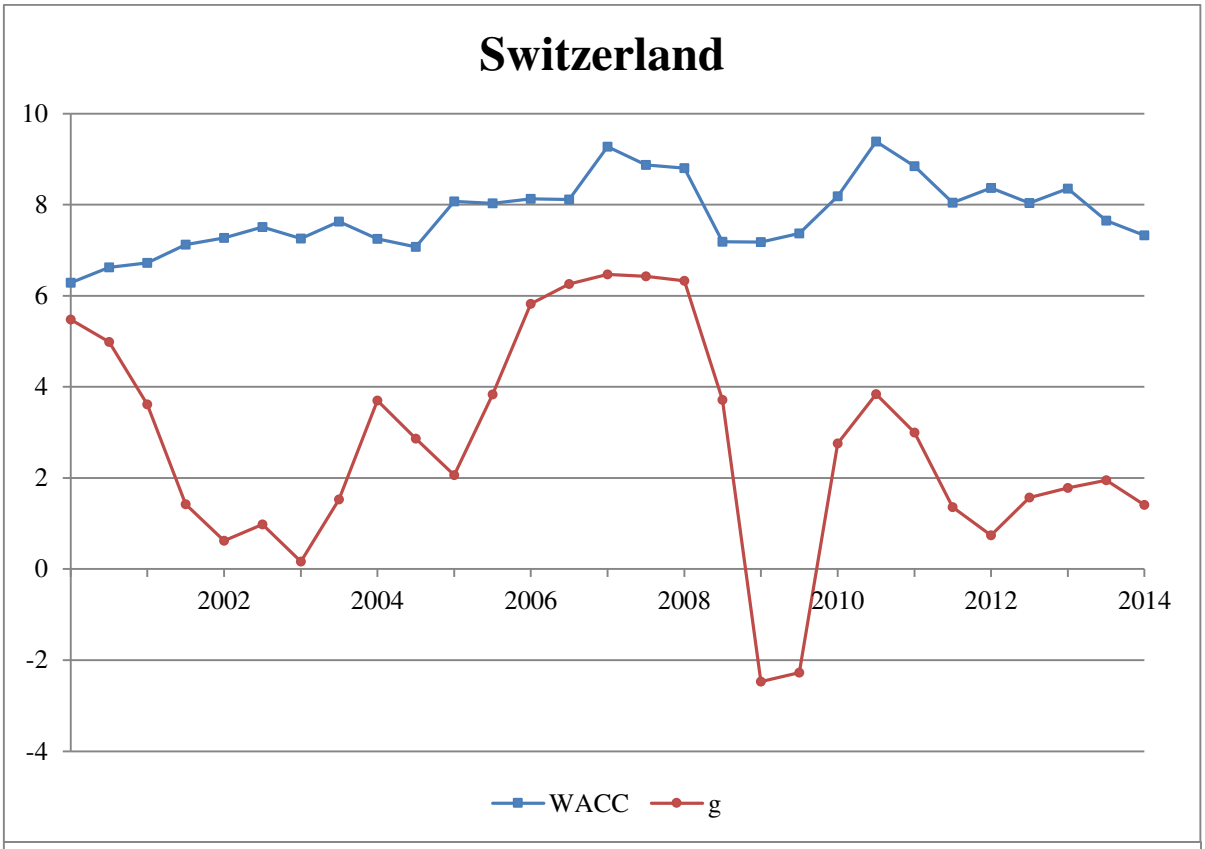
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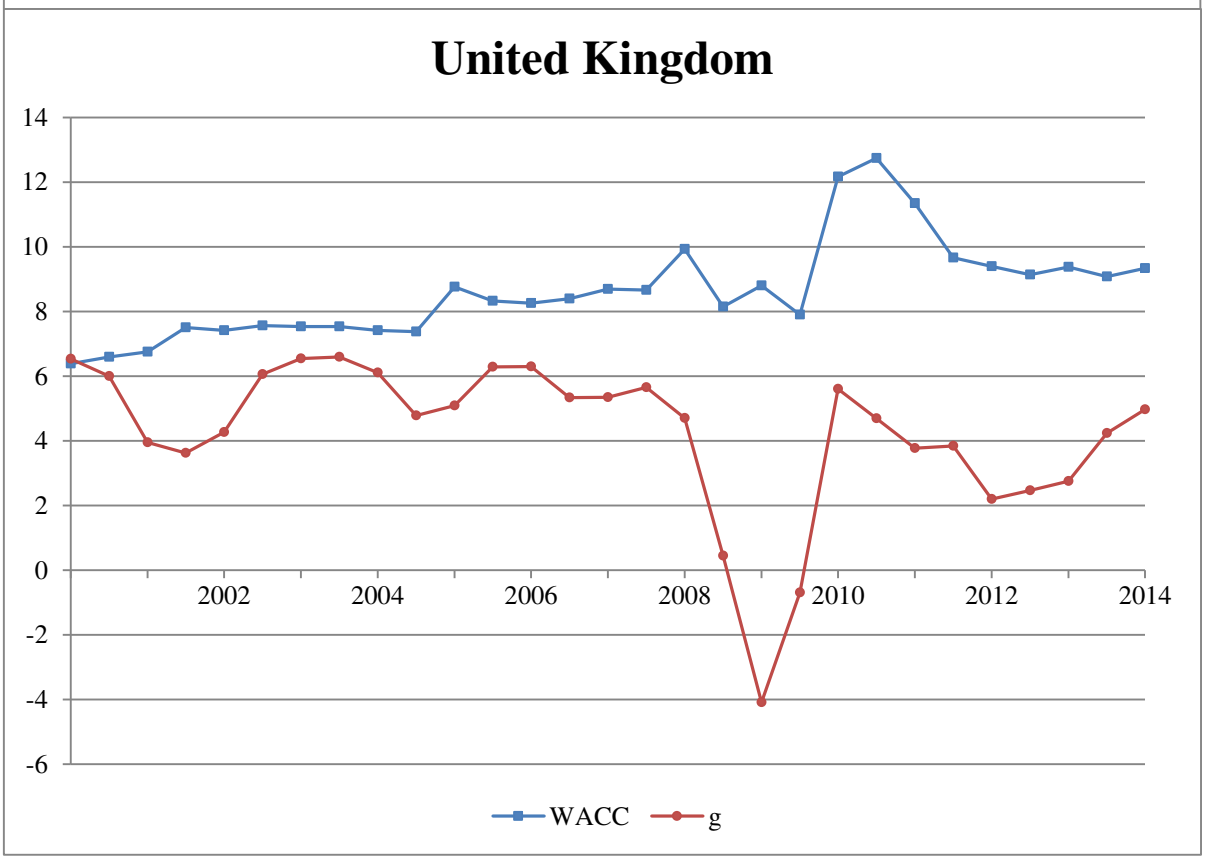
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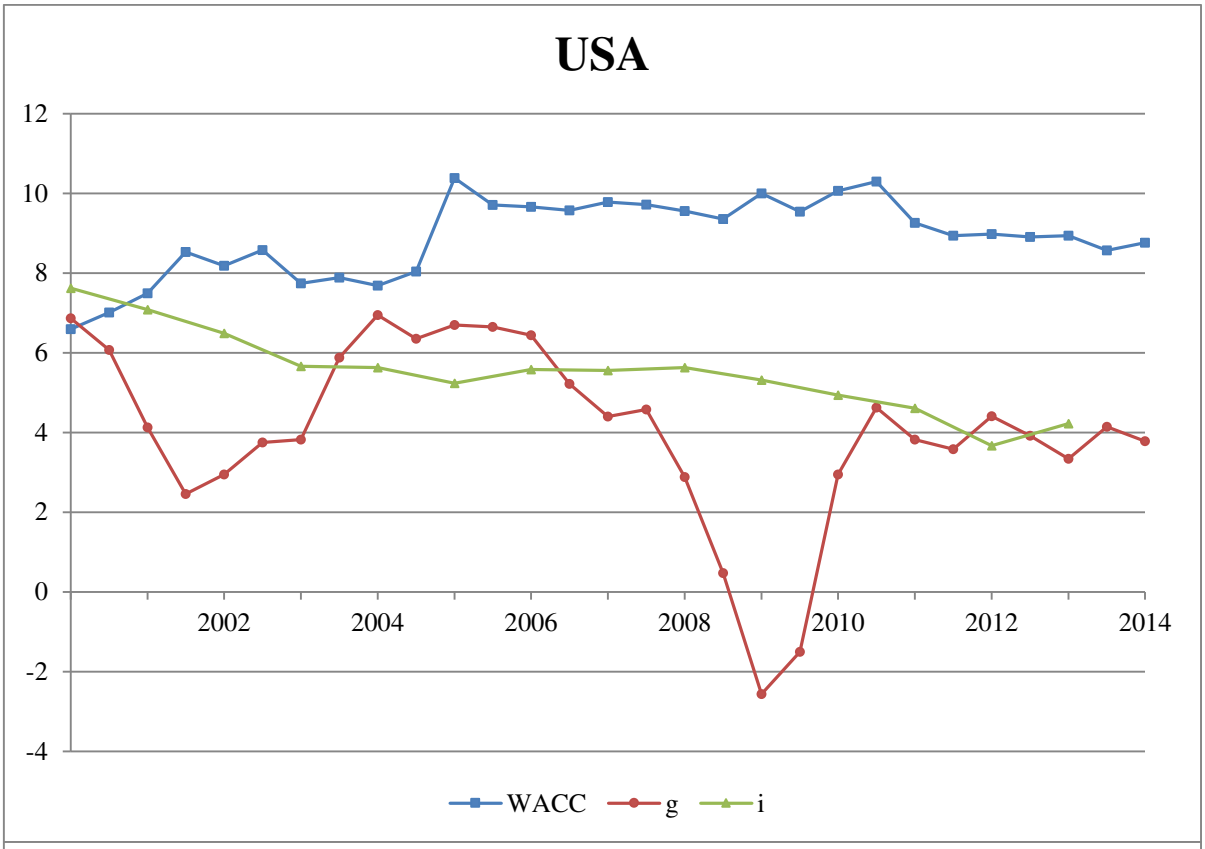
USA
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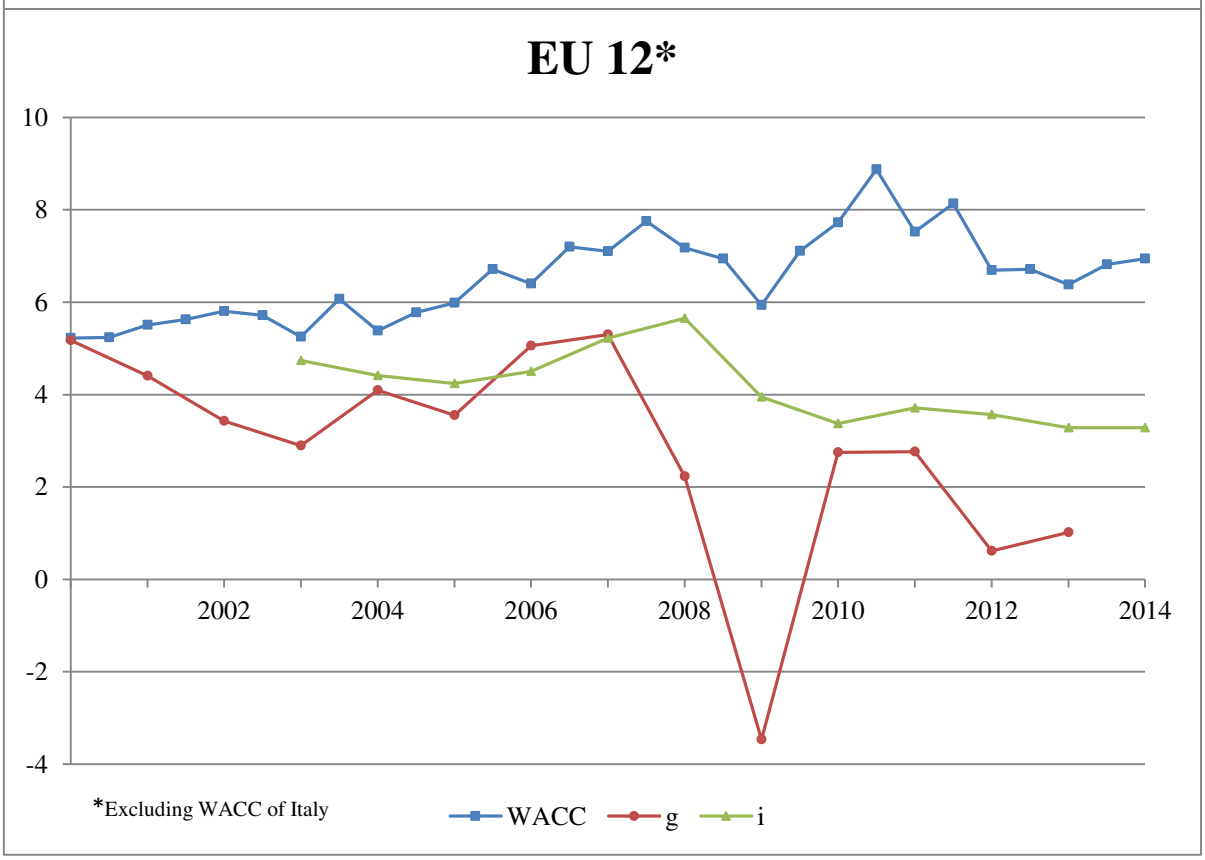
EU 12*
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2002
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*Excluding WACC of Italy
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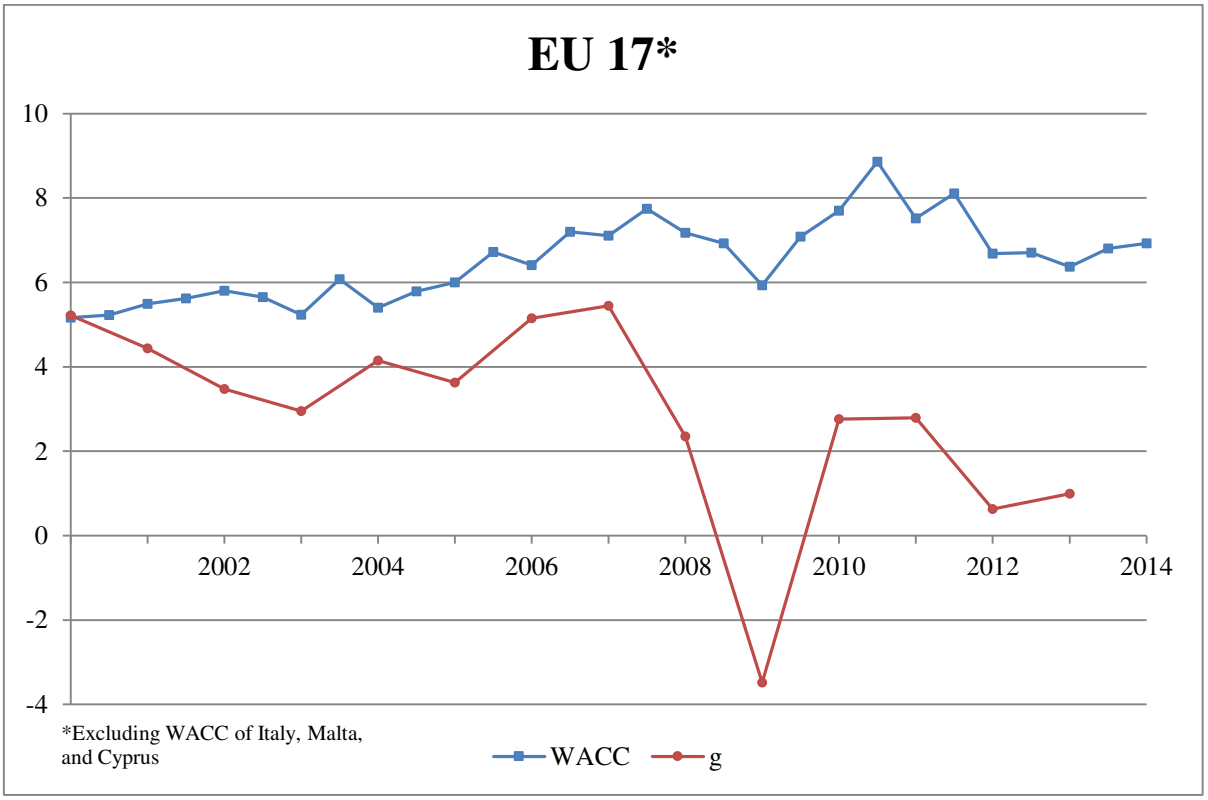

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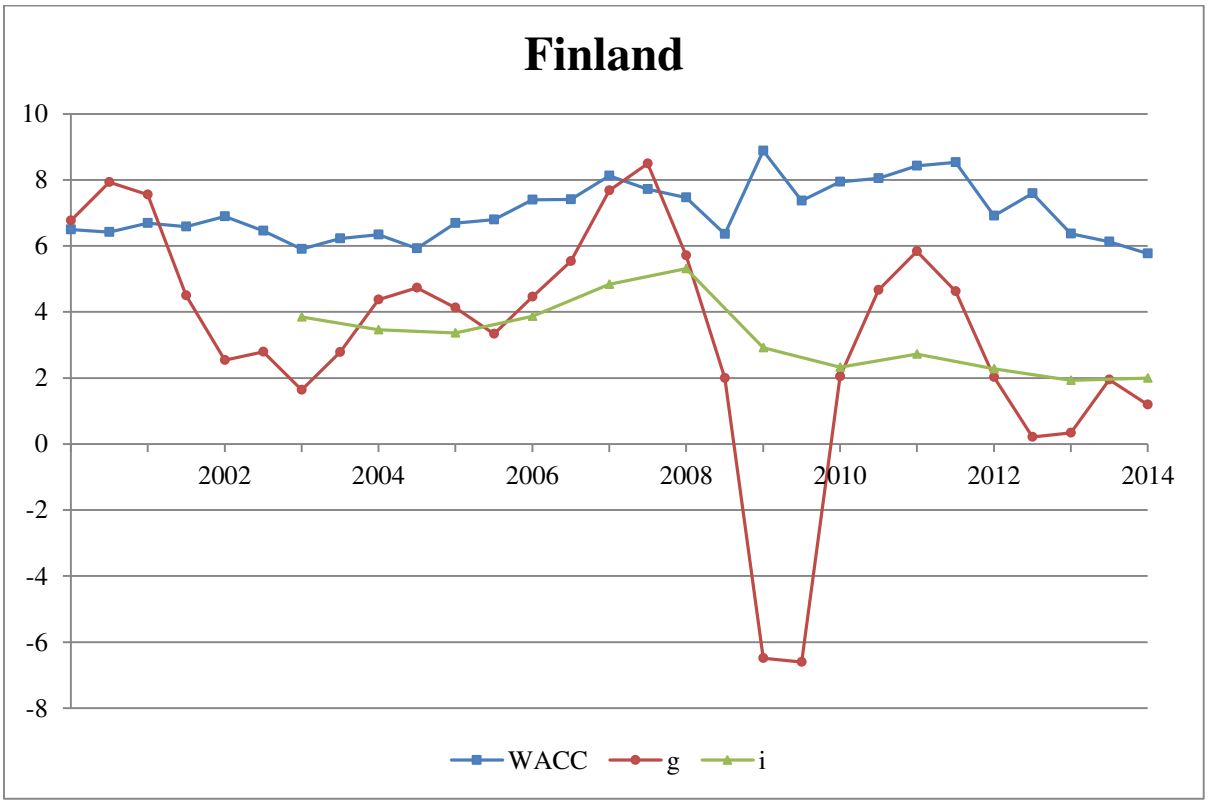

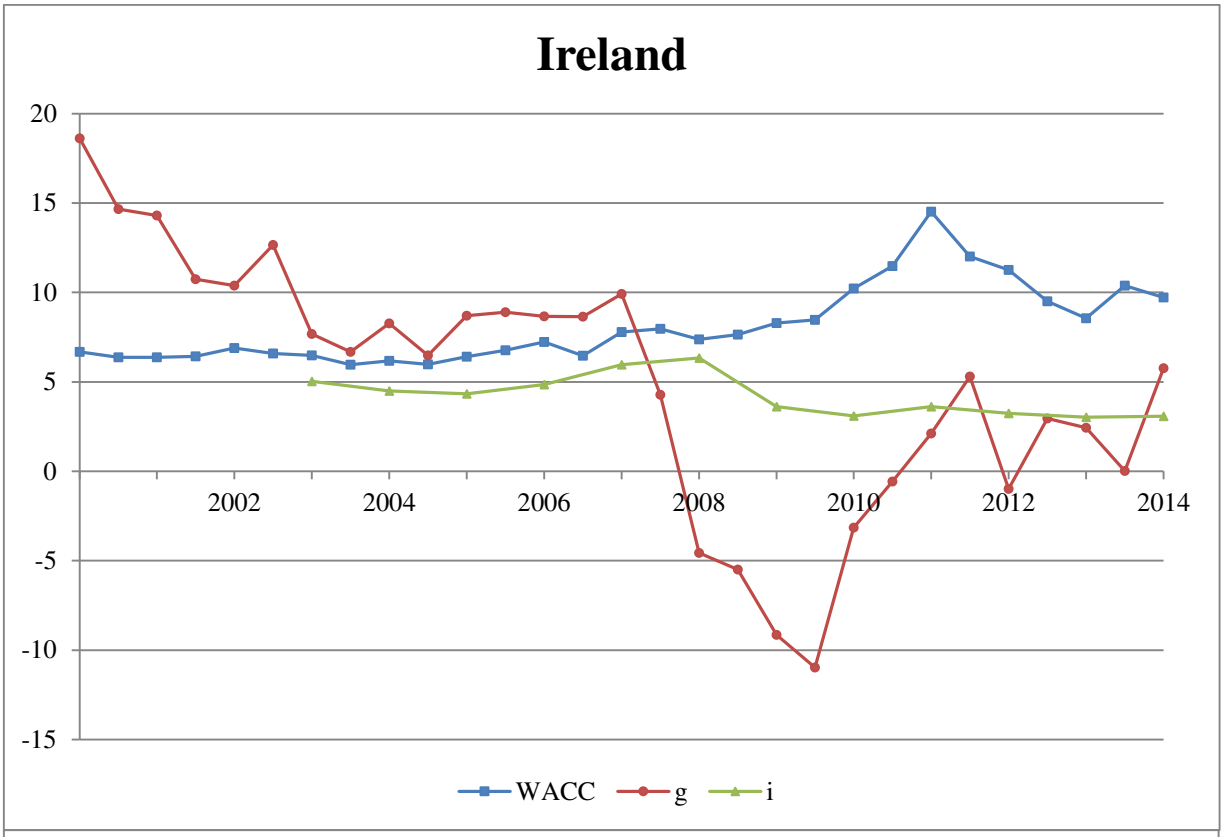
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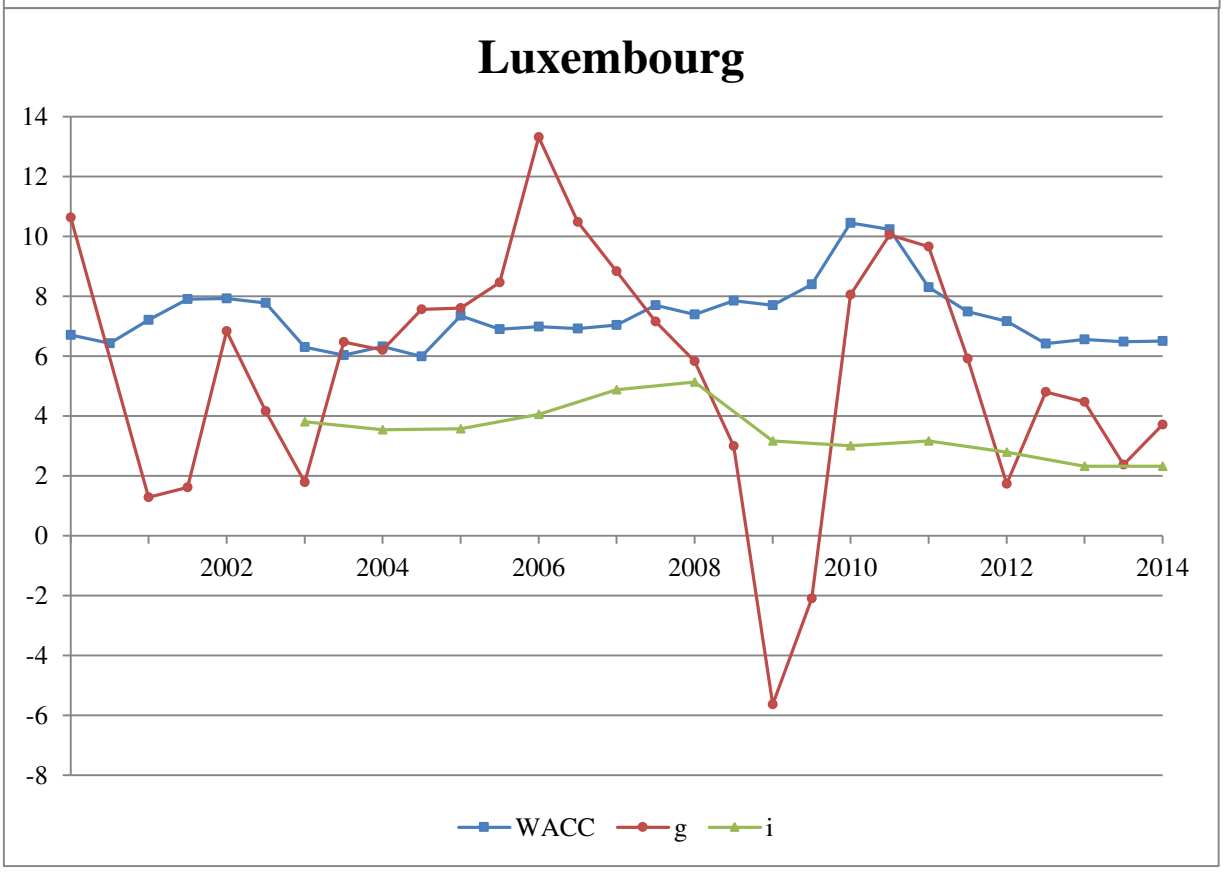
Luxembourg
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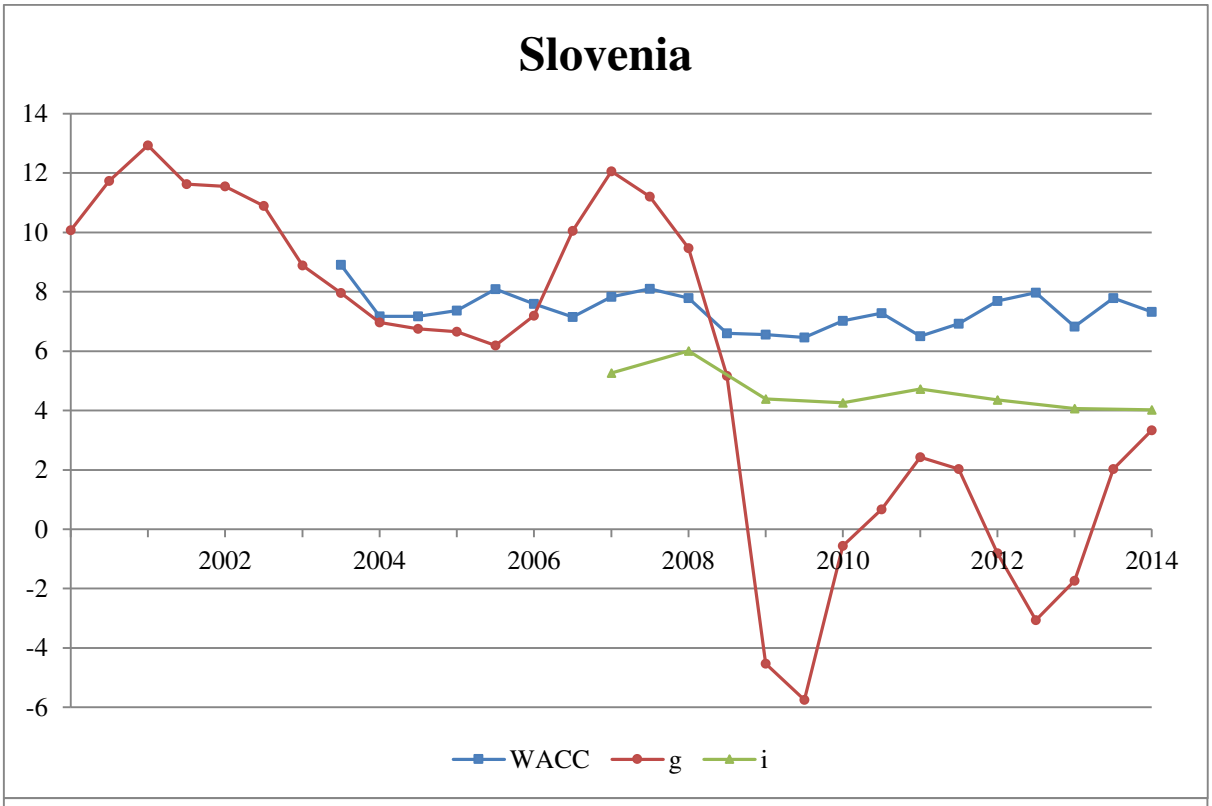
Slovenia
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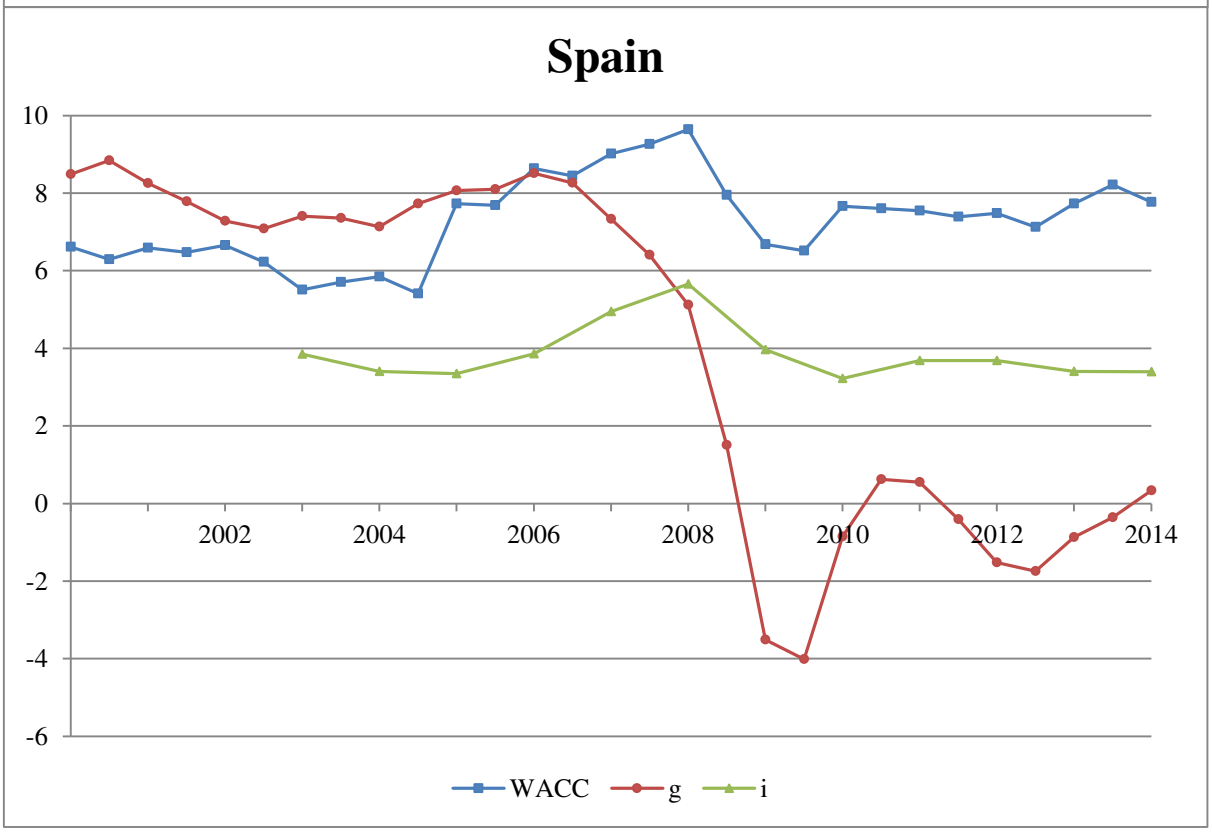
Spain
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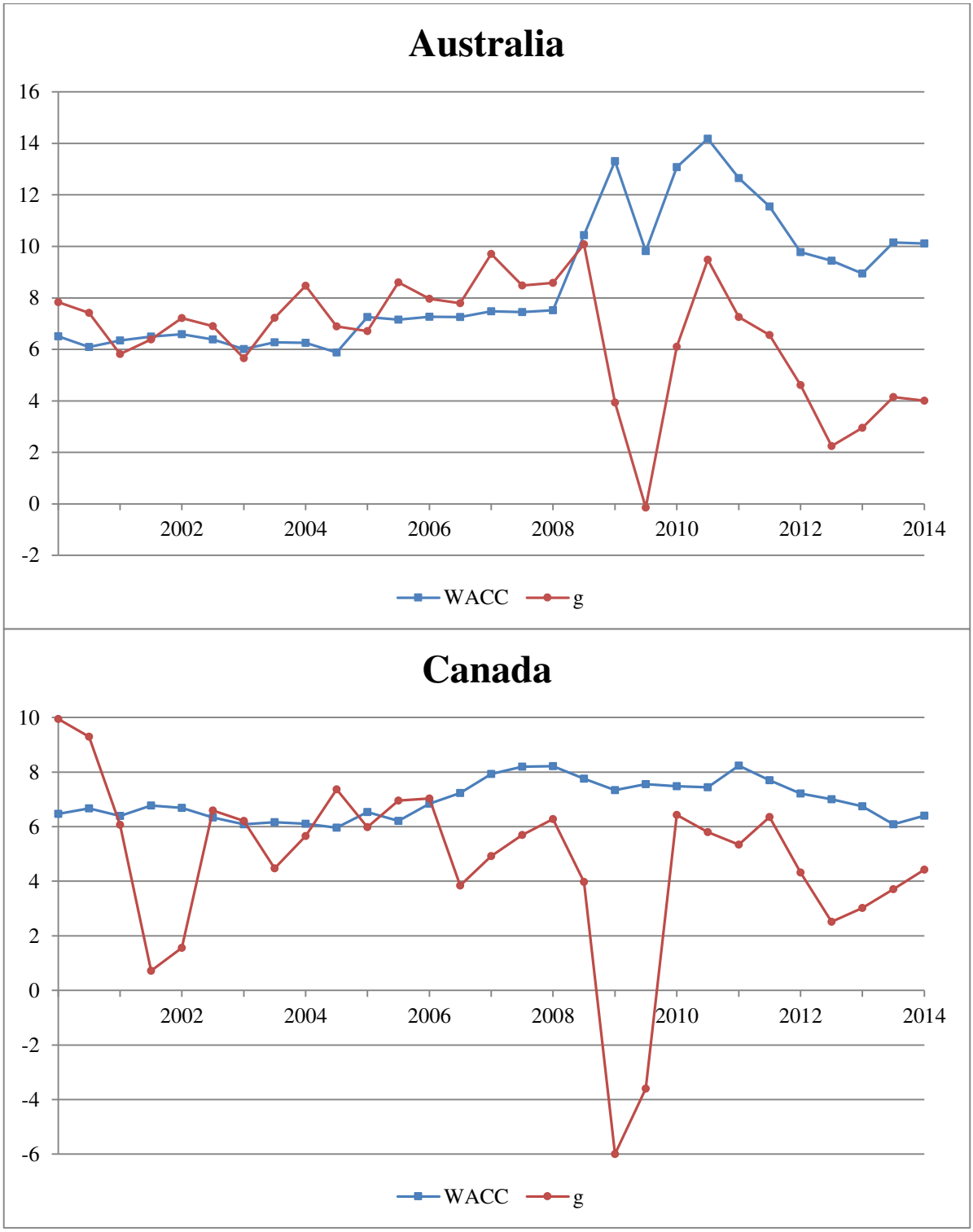
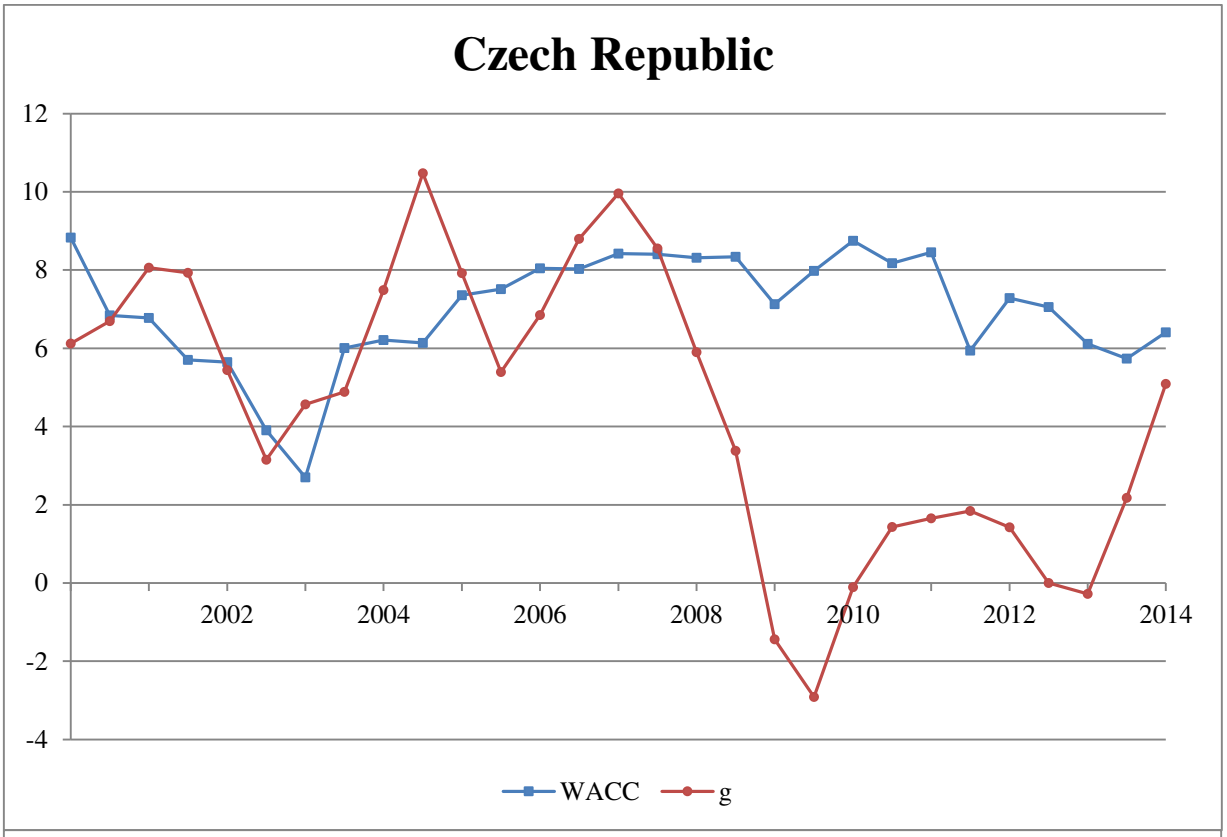
2.4. Category IV




Czech Republic
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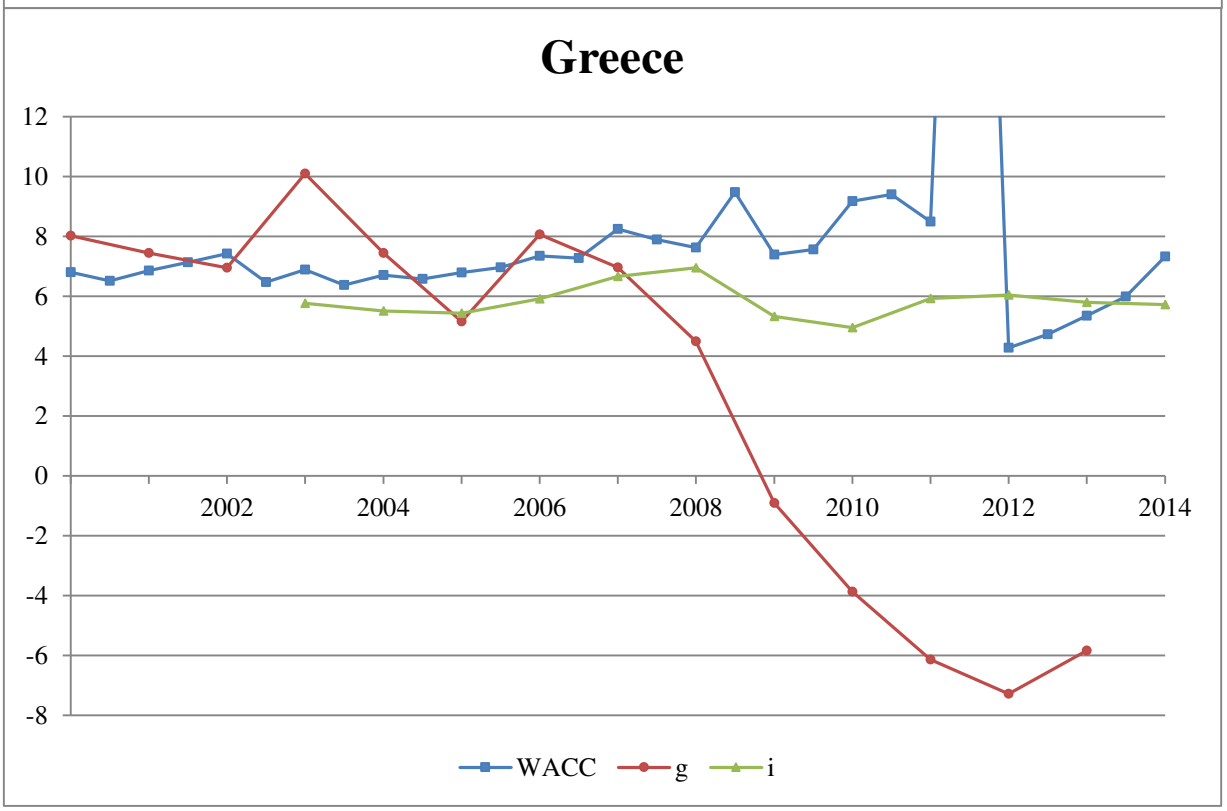
2012
2014
WACC
g


Greece
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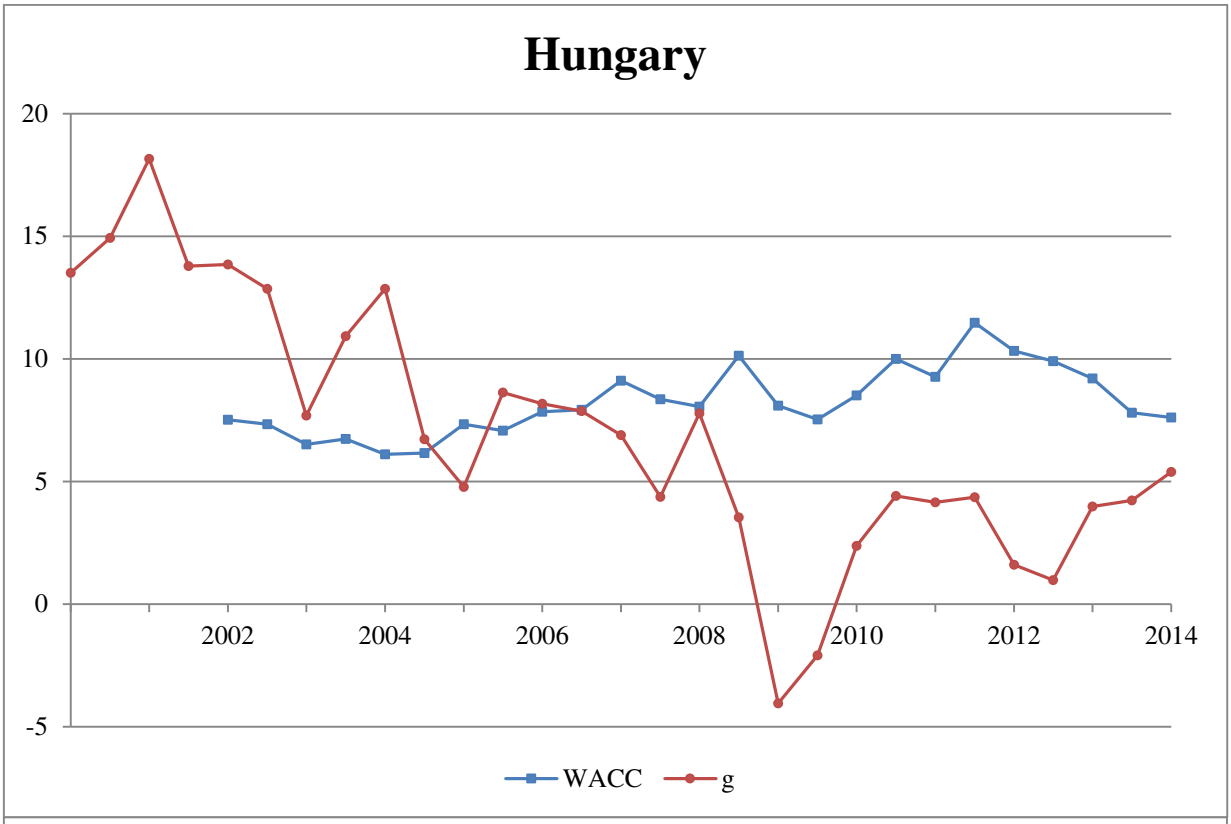
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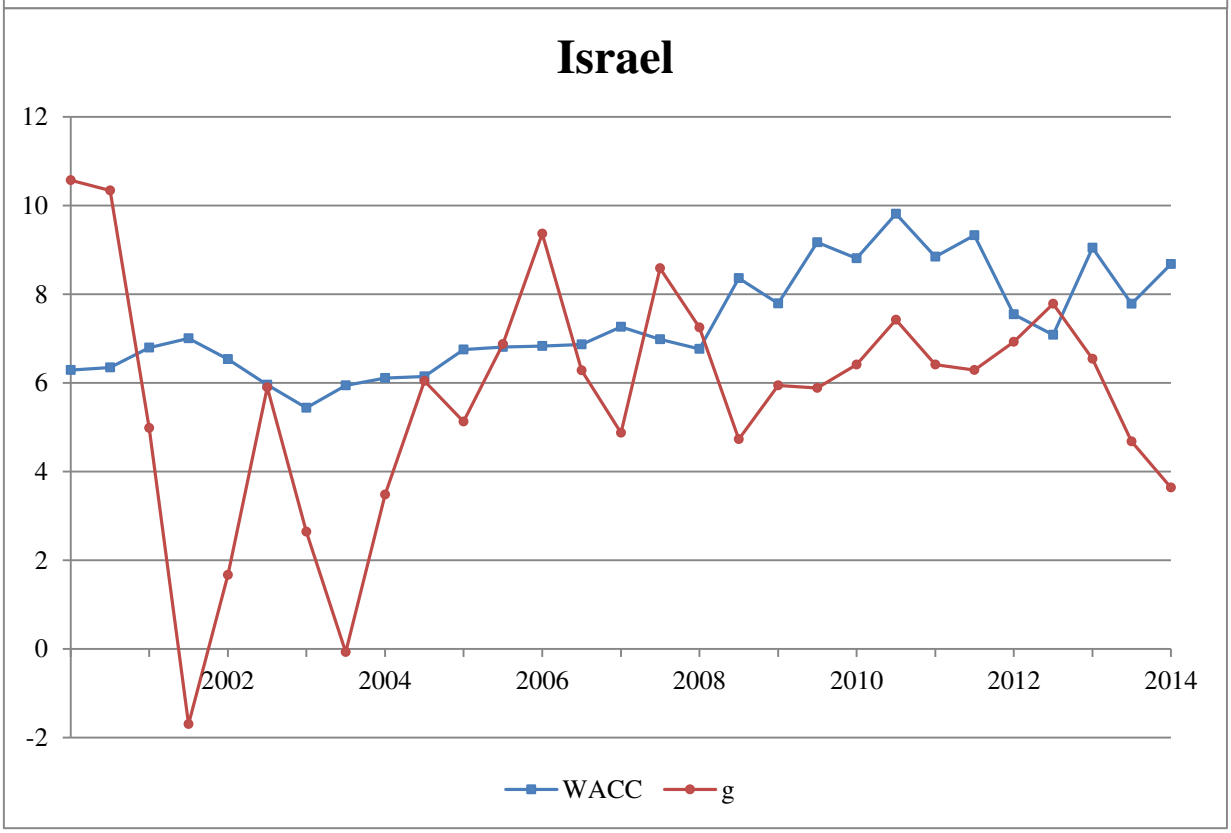
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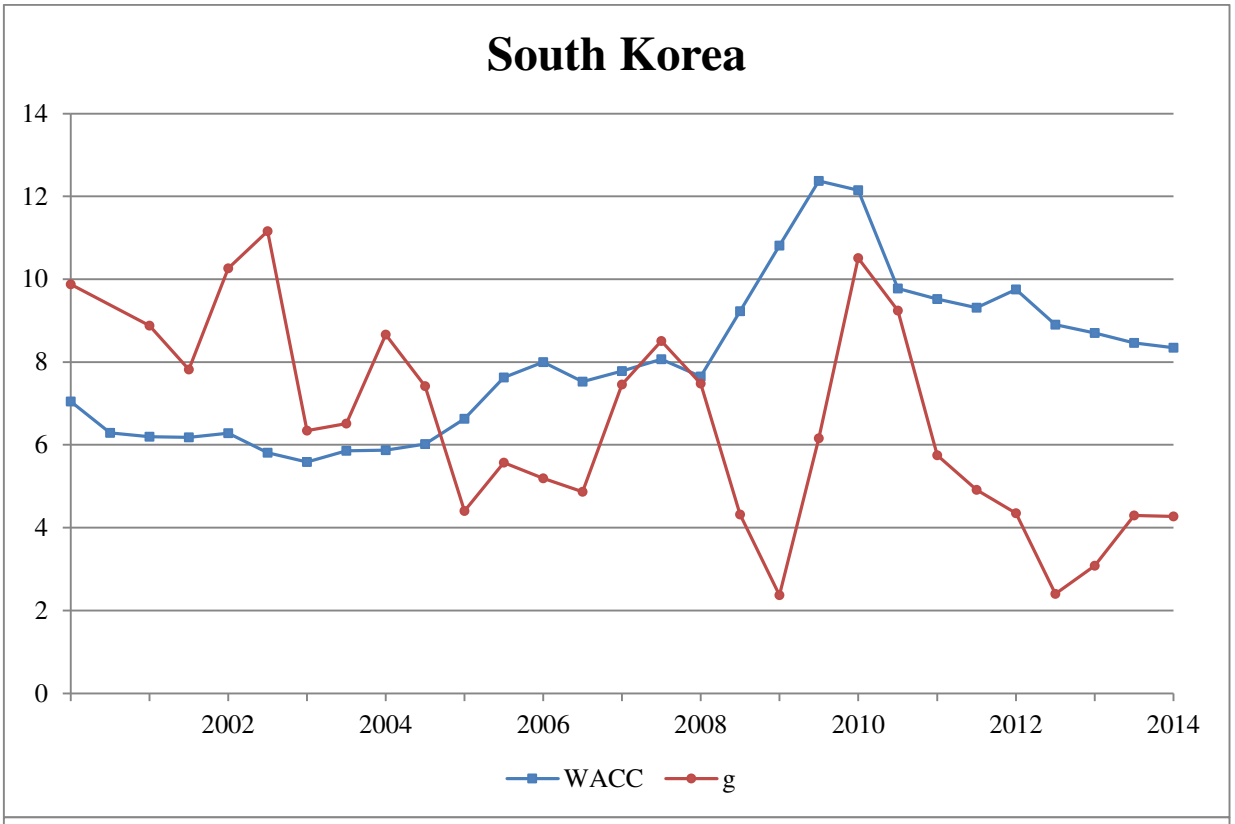
South Korea
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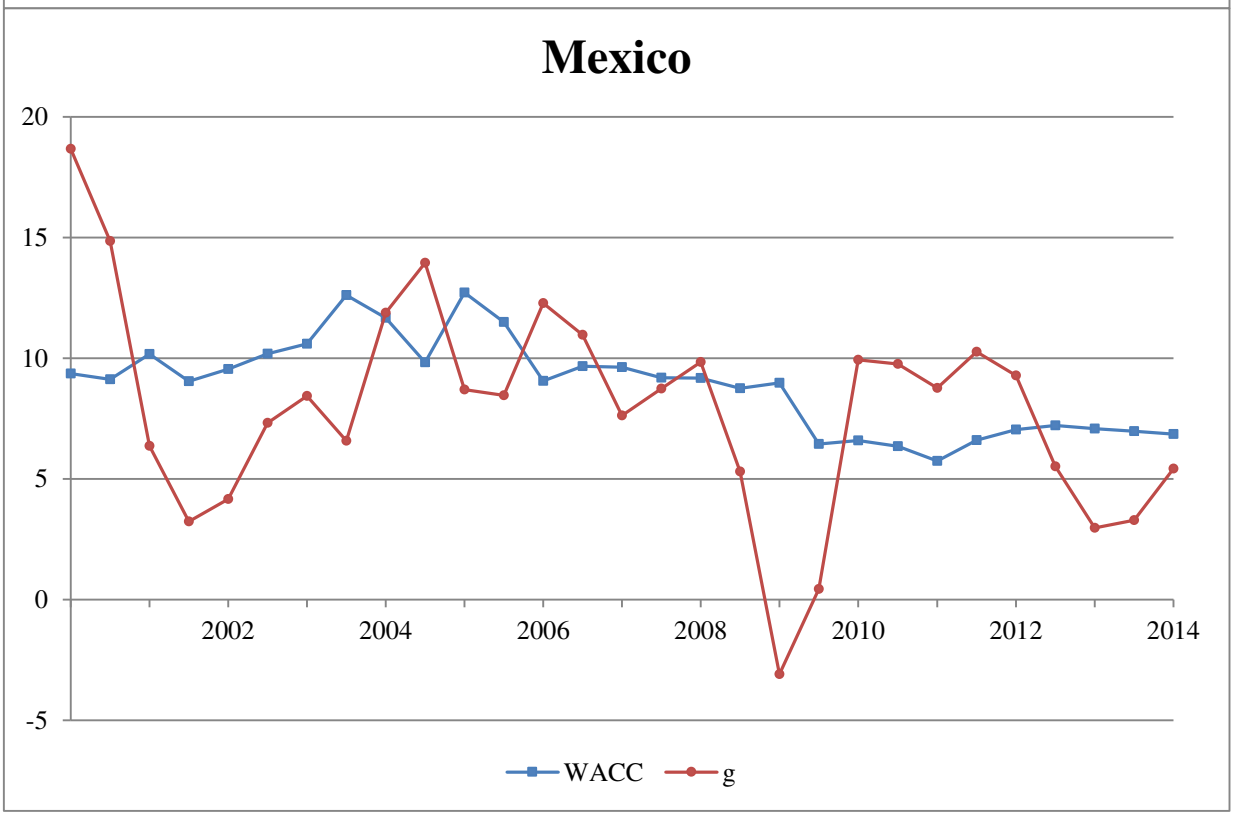
Mexico
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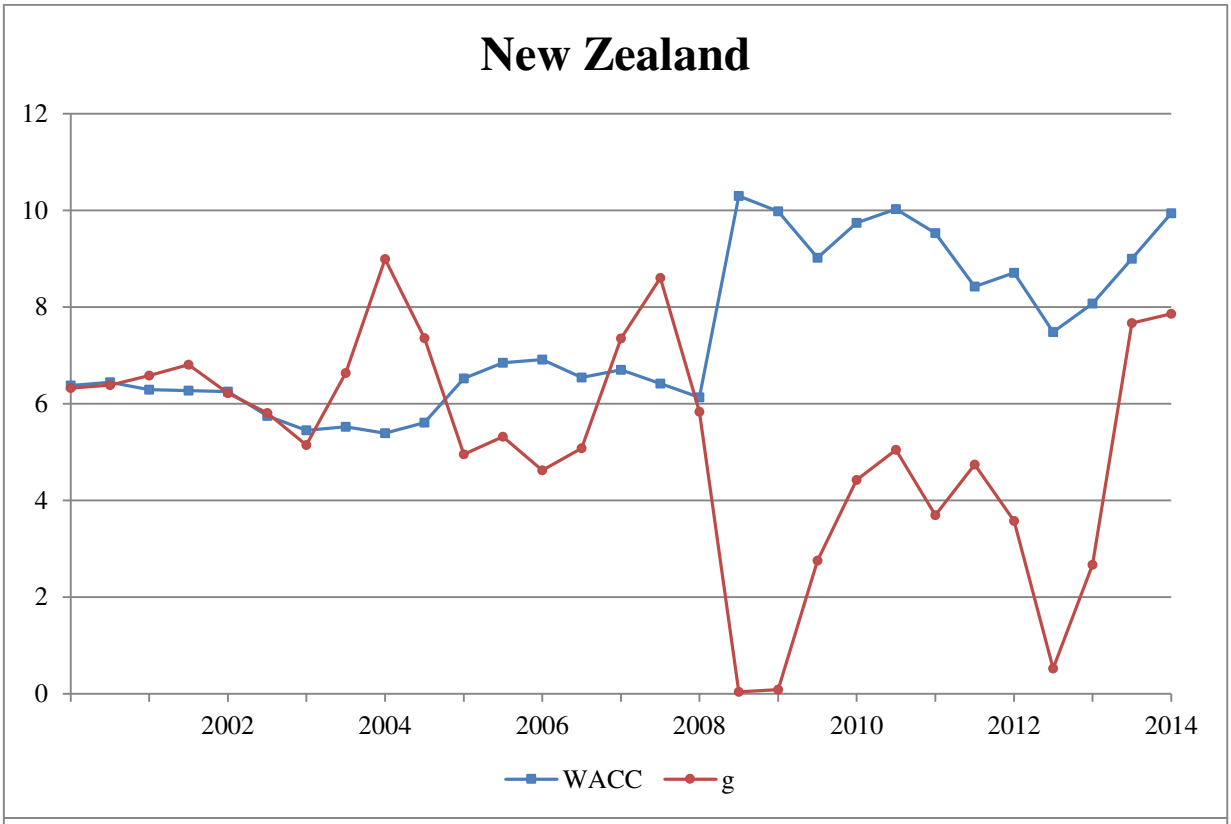
New Zealand
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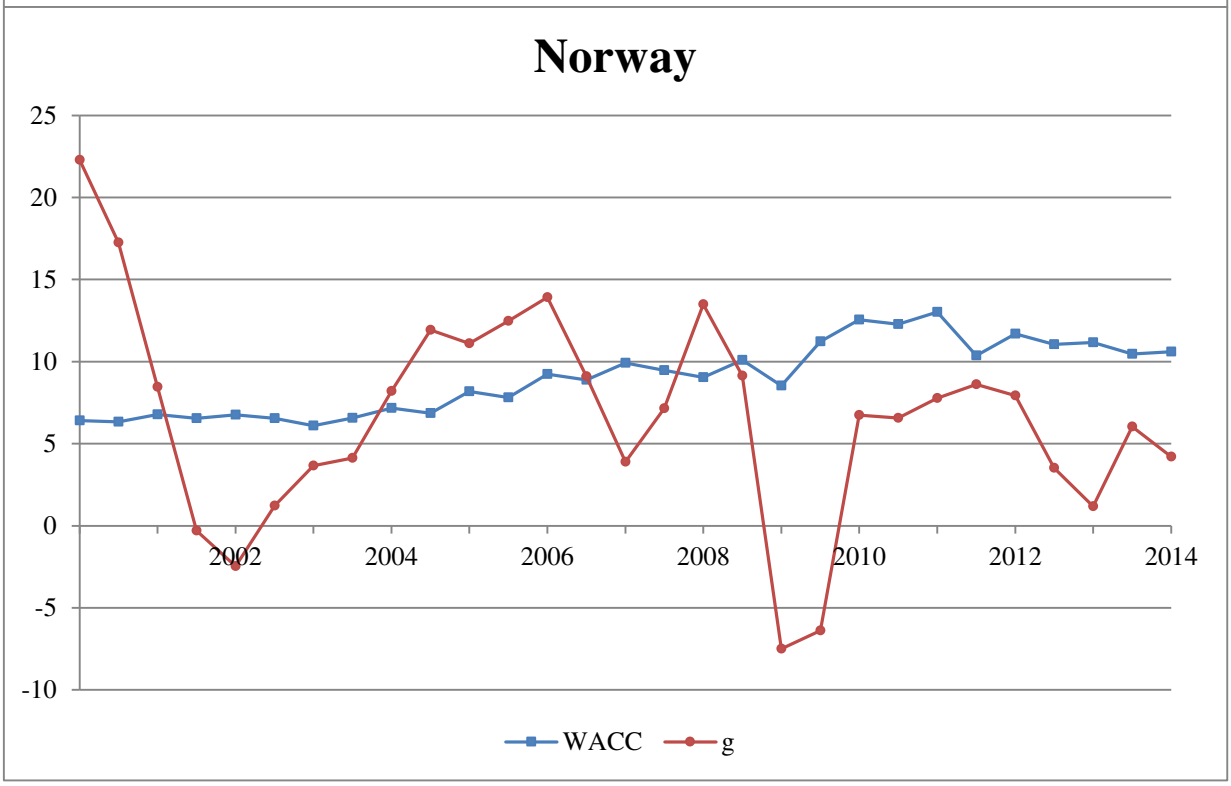
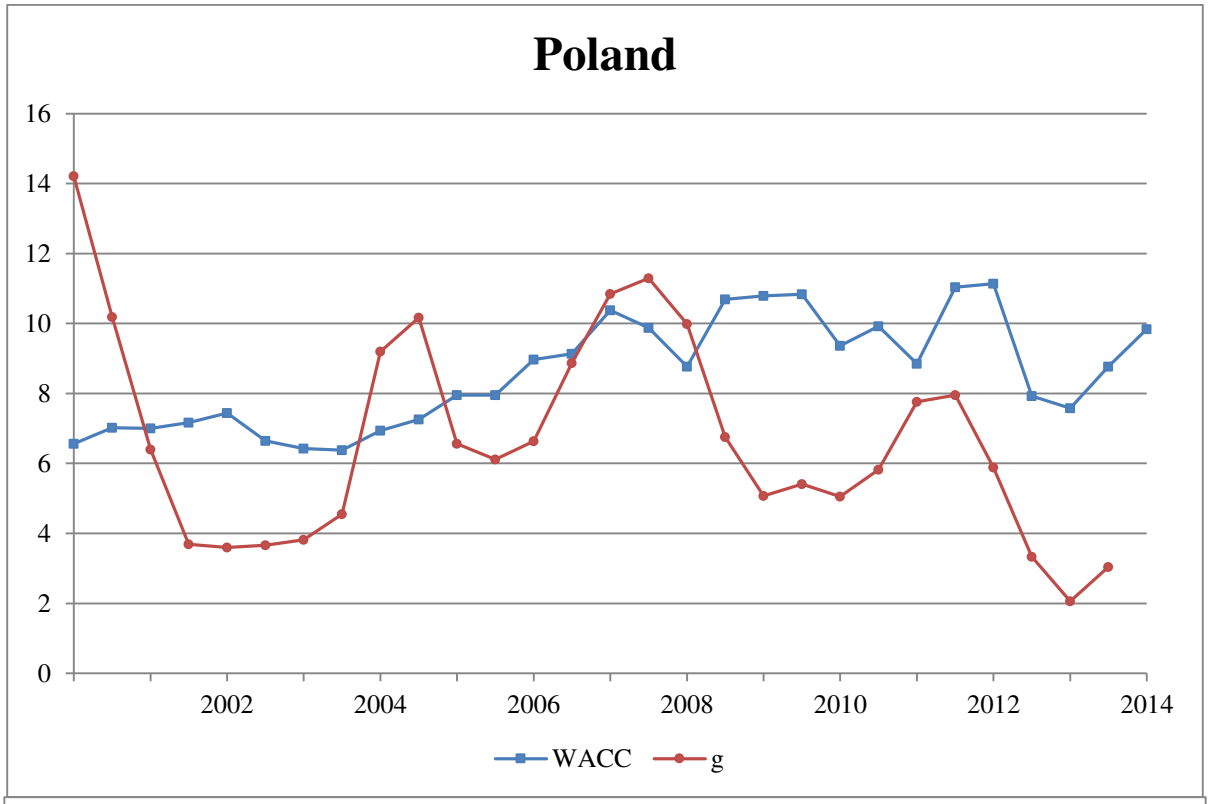
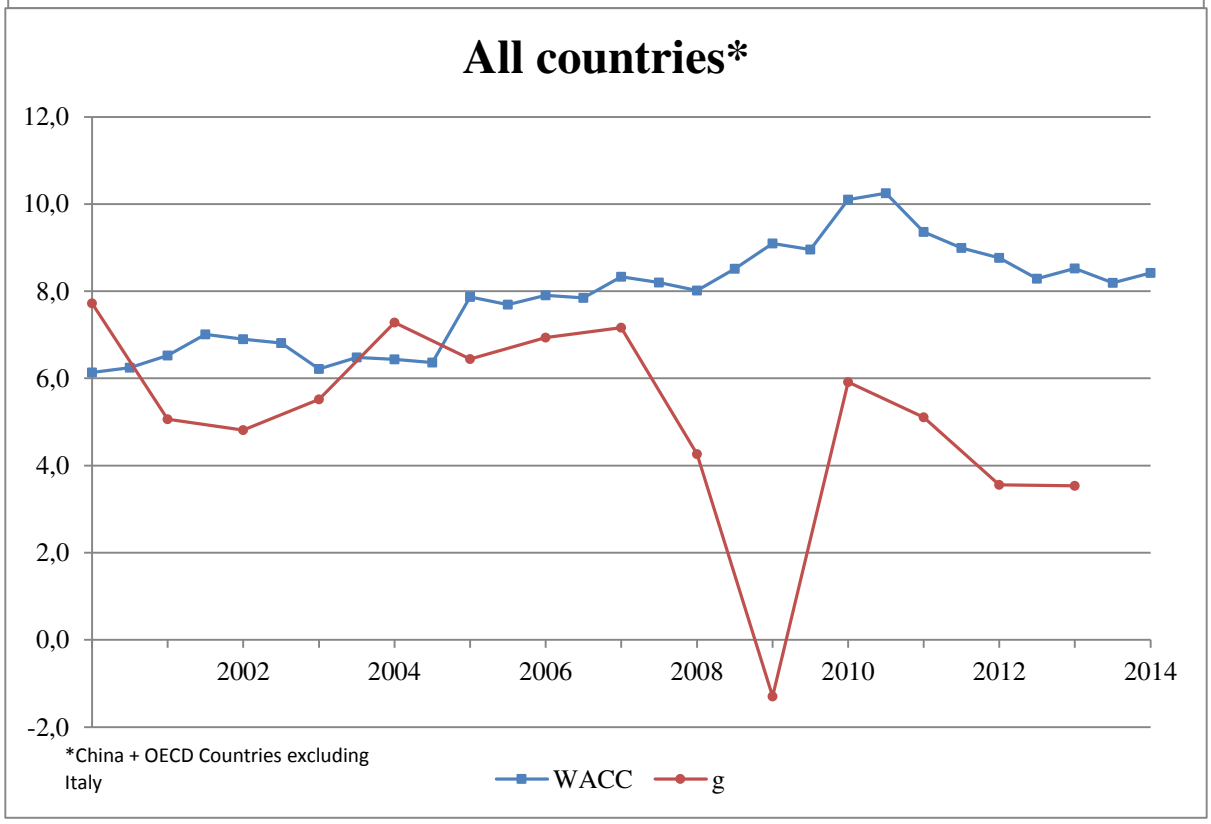
2014
WACC
g


Norway
25
20
15
10
5
0
-5
-10
2002
2004
2006
2008
2010
2012
2014
WACC
g


Poland
16
14
12
10
8
6
4
2
0
2002
2004
2006
2008
2010
2012
2014
WACC
g


All countries*
12,0
10,0
8,0
6,0
4,0
2,0
0,0
-2,0
2002
2004
2006
2008
2010
2012
2014
*China + OECD Countries excluding Italy
WACC
g