The Post-crisis Slump in Europe: A Business Cycle Accounting Analysis

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Abstract

This paper analyses the Post-crisis slump in 28 European economies during the 2008 - 2014 period using the Business Cycle Accounting (BCA) method à la Chari, Kehoe and McGrattan (2007). We find that the deterioration in the efficiency wedge is the most important driver of the European Great Recession and that this adverse shock persists throughout our sample. We further investigate the potential sources of efficiency loss and find that countries that have high pre-crisis per capita GDP growth rate, high perception of business opportunities harmed by state-owned enterprises, and low post-crisis trade to GDP ratio tend to have a smaller drop in efficiency.

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1. Introduction

After the onset of the global financial crisis in 2008, the European economy has been in a long-lasting economic slump characterized by persistent decline in economic activities. This paper analyses the post-crisis slump in 28 European economies during the 2008 - 2014 period using the Business Cycle Accounting (BCA) method à la Chari, Kehoe and McGrattan (2007).

The BCA procedure starts with defining efficiency, government, investment and labour wedges as residuals in the production function, the resource constraint, the capital Euler equation and the labour first order condition in a prototype dynamic stochastic general equilibrium model. Once all parameter values are pinned down through calibration and estimation, the model is solved numerically and the values of wedges can be backed out using the data of output, consumption, investment and labour. Finally, each wedge is fed into the model one-by-one in order to assess their impact on the business cycle.

The BCA method has been widely applied to the analysis of specific business cycles episodes in various countries. CKM (2007) focuses on the U.S. Great Depression and early 1980s recession. Klein and Otsu (2013) studies the International Great Depression during the interwar period. Kersting (2008) focuses on the UK recession in the 1980s. Kobayashi and Inaba (2006) and Chakraborty (2009) investigate the sources of the boom and bust in Japan during the 1980s and 1990s. Lama (2011) focuses on output drops in Latin America during the 1990s. Otsu (2010) studies the 1998 crises in East Asia. Cho and Doblas-Madrid (2013) compares 23 financial crisis episodes over the 1980 – 2001 period. Brinca (2014) studies 22 OECD countries over the 1970-2011 period. Most of these studies show that efficiency and labour wedges are important in accounting for output fluctuations.

Our paper contributes to the literature in several dimensions. First, we cover 28 European countries which allows us to draw a broad picture of the Great Recession in Europe. Next, we cover the period of 2008Q1 – 2014Q4 which allows us to assess not only the initial impact of the global financial crisis on Europe, but also the prolonged post-crisis slump. Finally, by applying the BCA method to each individual country, we can compare the importance of contributing factors across countries within Europe.

We find that the deterioration in the efficiency wedge is the most important driver of the European Great Recession and that this adverse shock persists throughout our sample. The second most important wedge is the labour wedge. Government wedges, as in existing literature, do not impact the economy in a significant way. And finally, investment wedges is not contributing to the recession in Europe. Therefore, the financial crisis must have operated through production efficiency and not through distortions in the investment market.

In order to investigate potential sources of the declines in efficiency wedges, we estimate the effects of several institutional variables on the drop in efficiency wedges over the 2007Q4–2014Q4 period. We find that countries that have high pre-crisis per capita GDP growth rate, high perception of business opportunities harmed by state-owned enterprises, and low post-crisis trade to GDP ratio tend to have a smaller drop in efficiency.

The remaining of the paper is structured as follows. Section 2 explains the data facts. Section 2 describes the BCA method underlying this paper. Section 4 presents the quantitative results. Section 5 concludes the paper.

2. Data

Our data set covers the following 28 European countries[2]:

Euro Area:

Austria	Belgium	Cyprus
Estonia	Finland	France
Germany	Greece	Ireland
Italy	Latvia	Luxembourg
Malta	Netherlands	Portugal
Slovakia	Slovenia	Spain

European Union: Euro Area plus

Czech Republic	Denmark	Hungary
Lithuania	Poland	Romania
Sweden	United Kingdom	

Europe: European Union plus

Iceland	Norway

Table 1. Sample countries

Quarterly data for output, consumption, investment, labour input, and adult population are obtained through *Eurostat*, using the European System of Accounts 2010-definition.[3] The data coverage goes from 1995Q1 up to 2014Q4. The data is obtained, where applicable, in real terms.

Private consumption is divided into consumption of non-durable goods, semi-durable goods, durable goods, and services. The final measure for private consumption contains the values for non-durable goods, semi-durable goods, and services. Durable goods expenditures are added to investment. Final total investment contains private investment, expenditures on durable goods, and public investment expenditures by the government.

[2] Bulgaria, Croatia, and Switzerland were dropped from the sample due to various data availability issues.
[3] If in some periods no data exists using the ESA 2010-definition, variable-to-GDP-ratios are obtained from the European System of Accounts 2005-definition and thereafter multiplied by the ESA 2010 output measure and extrapolated by their respective growth rates in order to fill the gaps until ESA 2010 data for this variable is available.

Total hours worked is normalized by the formula:

$$h = \frac{total\ hours\ worked}{adult\ population * 91.25 * 14}$$

Where 91.25 is the amount of days in one quarter of a year and 14 is assumed to be the maximum amount of hours that can be worked a day. This value tells us that the population is working a fraction of h from its potential maximum, and thus, the value must be between 0 and 1.

In order to define a stationary problem, all variables are detrended by their respective growth trends[4]:

$$y_t = \frac{Y_t}{N_t\Gamma_t}, c_t = \frac{C_t}{N_t\Gamma_t}, i_t = \frac{I_t}{N_t\Gamma_t}, h_t = \frac{H_t}{N_t}$$

Where lower case letters denote detrended per adult population values. N_t is the level of per adult population at time t, growing at the rate $(1 + n)$, and Γ_t is the level of labour augmenting technical progress in time t, growing at the rate $(1 + \gamma)$.[5]

Figure 1 shows us the time series of output (y), consumption (c), investment (i), and labour input (h) from 2007Q4 (the last period before the onset of the crisis) until 2014Q4.[6] All data series are detrended, logged and normalised as 2007Q4=0 so that they are measured as the log deviation from their respective trend. The solid line with circular markers is the observed mean value of the data while the dashed line is a 95% bootstrap confidence interval.

We can clearly see that output and consumption starts a rapid decline in the first few quarters of the crisis. This decline lasts until the end of the observation period in the last quarter of 2014. It is important to recognise that both variables do not seem to stabilise throughout this seven-year period. At the end of 2014, average output in Europe dropped almost 24% and consumption dropped almost 25% relative to its pre-crisis trend level.

Investment on the other hand shows an even more radical picture. It drops in the first six periods of the crisis by almost 35%, and is therefore more than three times the size of the drop in output during the same period. It stabilises somewhat after that just to drop by another 20% in mid-2011. At the beginning of 2013 it stabilises again and remains at this level of almost negative 50% until the end of 2014. As seen by the confidence interval, some countries even experience a drop in investment expenditures of almost 60% compared to their pre-crisis trend level.

Labour input, as measured by total hours worked per capita, sees an increase of almost 2% at the beginning of the crisis. After this increase it goes into steep decline until the beginning of 2013 and remains at the level of around negative 7% until the end of the observation period.

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[4] Output, consumption and investment should grow at the rate of adult population and labour augmenting progress along the balanced growth path. Total hours worked is only detrended by adult population, since its only trend comes from the growth in population and not from the growth in labour augmenting technical progress.

[5] The growth rate of per adult output must be equal to the growth rate of labour augmenting technical progress along the balanced growth path.

[6] Remember that all variables are detrended and in per capita terms.

The observed declines in these four variables clearly show the post-crisis slump in Europe. The main purpose of this study is to find out what the propagation mechanism is that drives the destructive performance of these variables.

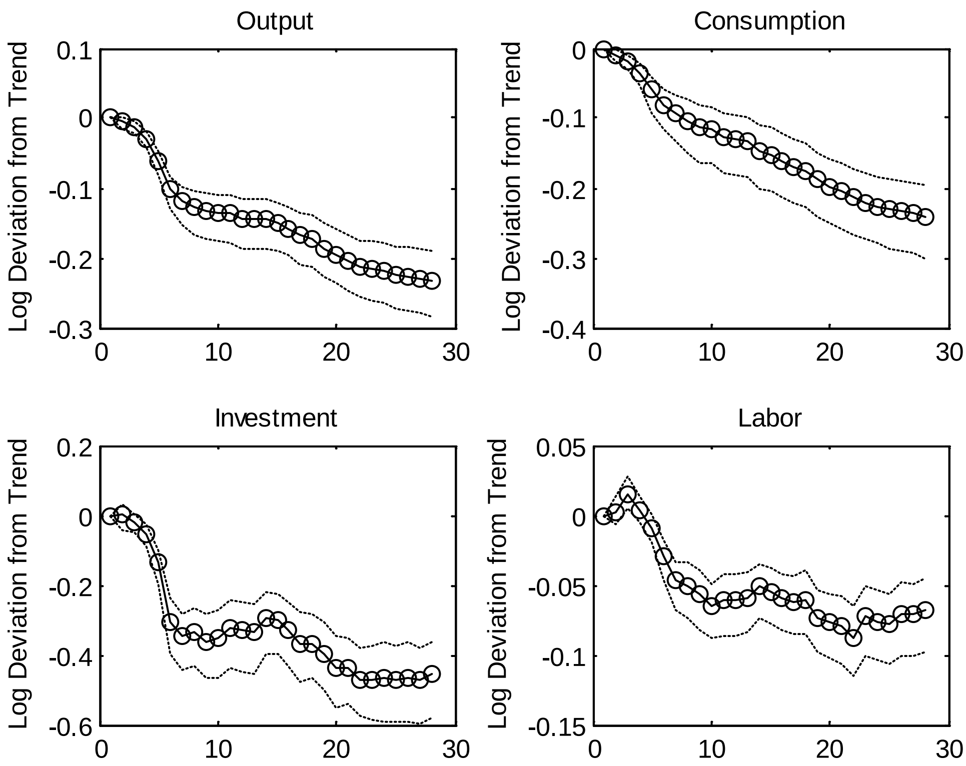

Figure 1. Time series of economic variables

3. Benchmark Prototype Model

The benchmark prototype model is a closed economy flexible price model with market distortions. The representative household decides in every period over how much to consume, invest in capital stock, and work or enjoy leisure. The production sector is characterised by a representative firm that intents to maximise profits by periodically choosing how much labour to hire and how much capital to invest. The production technology of the firm is represented by a constant-returns to scale production function which is impacted by time-varying production efficiency. The government sector collects taxes and channels them directly back to the consumer in form of lump-sum transfers.

3.1 Household's problem

The representative consumer maximises expected lifetime utility via the following problem:

$$maxE_t\sum_{t=0}^{\infty}\beta^t u(c_t, 1-h_t)$$

The representative household gains utility from choosing consumption in time t, c_t, and leisure, as a measure of total available working hours, normalised at 1, minus actual hours worked at time t, h_t:

$$u(c_t, 1-h_t) = \psi lnc_t + (1-\psi)\ln(1-h_t) \tag{1}$$

Ψ is a time allocation parameter.

The household's budget constraint is:

$$(1-\tau_{ht})w_t h_t + r_t k_t + \pi_t + \tau_t = c_t + (1+\tau_{it})i_t \tag{2}$$

Where w_t is the wage rate at time t, r_t the real interest rate at time t, k_t the capital stock at time t, π_t profits gained by the firm and paid back to the owner of the firm at time t, τ_t lump-sum transfers paid by the government at time t, and i_t is gross capital investment expenditures at time t. τ_{ht} and τ_{it} are the tax rates for wages and investment, respectively.

The budget constraint, equation (2), tells us that the consumer's consumption and saving's decision must not exceed his income, which consists of his labour income, capital income, profits, and transfers received from the government.

And subject to the capital law-of-motion:

$$\Lambda k_{t+1} = i_t + (1-\delta)k_t$$

Where, as before, k is capital stock in time t and t+1, i_t gross capital investment expenditures, and δ the depreciation rate. Λ is the total growth rate of the economy and can be decomposed into population growth and the growth due to increased total factor productivity.

3.2 Firm's problem

The firm maximises profits:

$$max\pi_t = y_t - w_t h_t - r_t k_t \tag{3}$$

by choosing labour input, h_t, and capital, k_t, and thereby determining output, y_t, subject to the production function:

$$y_t = z_t k_t^{\theta} h_t^{1-\theta}$$

Where z_t is the time-varying production efficiency, and θ and (1- θ) capital and labour intensity, respectively. Since we assume a constant returns to scale technology, we know that θ plus (1- θ) must equal to 1.

3.3 Government

The government sector collects taxes and channels them directly back to the consumer in form of lump-sum transfers. Hence, the government's budget constraint is:

(4)

$$\tau_{ht} w_t h_t + \tau_{it} i_t = \tau_t + g_t$$

Where, as before, τ_{ht}, τ_{it} are the tax rates for wages and investment, respectively, and τ_t lump-sum transfers paid to the household. g_t is government consumption.

In order to obtain the economy's equilibrium resource constraint, we simply need to substitute the government budget constraint (4) and the firm's problem (3) into the household budget constraint (2). We obtain:

$$y_t = c_t + i_t + g_t$$

3.4 Equilibrium

A general competitive equilibrium in this model occurs if there is a sequence of prices and taxes $\{w_t, r_t, \tau_{ht}, \tau_{it}\}$ from t=0 up to ∞ and quantities $\{z_t, c_t, h_t, k_{t+1}\}$ from t=0 up to ∞ such that:

i. The household maximises utility taking as given the prices, taxes and an initial value of k_0;
ii. the firm maximises profits taking prices and productivity as given in the market;
iii. labour and capital markets clear for every period;
iv. resource constraint, equation (8), holds for every period;
v. the exogenous variables follow a stochastic process

Formally the equilibrium can be represented in a state where all of the following equations hold:

$$\frac{1-\psi}{\psi}\frac{c_t}{1-h_t} = (1-\tau_{ht})(1-\theta)\frac{y_t}{h_t} \quad (5)$$

$$\frac{1}{1+\tau_{it}} = \frac{\beta}{\Lambda}E[\frac{c_t}{c_{t+1}}(\theta\frac{y_{t+1}}{k_{t+1}} + \frac{1}{1+\tau_{it+1}}(1-\delta))] \quad (6)$$

$$\Lambda k_{t+1} = i_t + (1-\delta)k_t \quad (7)$$

$$y_t = c_t + i_t + g_t \quad (8)$$

$$y_t = z_t k_t^{\theta} h_t^{1-\theta} \quad (9)$$

Where equation (5) is the *intra*-temporal First-order condition of labour, or the relation between the Marginal Rate of Substitution between consumption and leisure and the Marginal Product of Labour, distorted by the labour income tax, τ_{ht}.

Where equation (6) is the *inter*-temporal capital Euler equation, or the relation between the Marginal Rate of Substitution between consumption today and tomorrow and the Marginal Product of Capital, distorted by the investment tax τ_{it} and τ_{it+1}.

Equations (7), (8), and (9) are the capital law-of-motion, the resource constraint, and the production function, respectively, as discussed before.

τ_{ht}, τ_{it}, and τ_{it+1} are the labour wedge and the investment wedge, correspondingly, in time t and time t+1.[7]

3.5 Wedges

There are four stochastic and exogenous distortions, or wedges, that create deviations in either the first order equilibrium conditions of the model, in the relationship between input and output factors, or in the goods available in the economy:

a) Efficiency wedge, ω_{At}

The efficiency wedge is the relationship between the output produced in an economy given its input. It, hence, tells us something about the efficient use of limited factors of production. More commonly, the efficiency wedge can also be called *Total Factor Productivity*, and can be represented as follows:

$$\omega_{At} = z_t = \frac{y_t}{k_t^{\theta} h_t^{1-\theta}}$$

The efficiency wedge might fluctuate either due to shocks to technology, e.g., the invention of new processes or the innovation of existing ones; due to the accumulation or contraction of human capital; or due to shocks to the prices of intermediate goods like crude oil.

b) Labour wedge, ω_{ht}

The labour wedge can be represented as a friction in the *First-Order Labour Equation* of the household. More accurate, it drives a wedge between the Intra-Temporal Marginal Rate of Substitution of consumption and leisure, and the Marginal Product of Labour, which is in a world of perfect competition equal to the prevailing wage rate in the labour market:

$$\frac{1-\psi}{\psi}\frac{c_t}{1-h_t} = \omega_{ht}(1-\theta)\frac{y_t}{h_t}$$

Or equivalently:

$$MRS_{ct,lt} = \omega_{ht} MPL_t$$

The labour wedge can represented as a tax on labour income, therefore the change from $(1-\tau_{ht})$ in the household's budget constraint (2) into ω_{ht} in equation (5). This transformation has been done because it is important to understand at this point that taxes, which were levied on labour income, only represent one of many frictions that might distort the first-order condition of labour. Cho and Doblas-Madrid (2013) argue that the entire set of wedges, and not only the labour wedge in particular, represents all kinds of frictions, distorting the

[7] The equilibrium of the model is step by step derived in the appendix.

first-order conditions, the resource constraint, or the production function. In case of the labour wedge, not only labour-income tax, but also monopoly power of firms and labour unions, or nominal rigidities are possible causes for sub-optimal behaviour.

c) Government wedge, ω_{gt}

The government wedge is defined as the difference between the goods produced in an economy, and the goods available to its domestic economic agents. In terms of the model used in this paper:

$$y_t - c_t - i_t = g_t = \omega_{gt}$$

Since we only obtain data for output, private consumption and private and public investment, we calculate government consumption as a residual term.[8]

d) Investment wedge, ω_{it}

The investment wedge can be represented as a friction in the *First-Order Capital Euler Equation*. More accurate, it drives a wedge between the Inter-Temporal Marginal Rate of Substitution of consumption today and consumption tomorrow, and the Marginal Product of Capital, which is in a world of perfect competition equal to the real interest rate (*r*):

$$\omega_{it} = \frac{\beta}{\Lambda} E[\frac{c_t}{c_{t+1}}(\theta \frac{y_{t+1}}{k_{t+1}} + \omega_{it+1}(1-\delta))]$$

Or equivalently:

$$\omega_{it} = E[\frac{MPK_{t+1} + \omega_{it+1}(1-\delta)}{MRS_{ct,ct+1}}]$$

Following the same argument as in point b), the investment wedge can represented as a tax on investment expenditures, therefore the change from $1/(1+\tau_{it})$ in the household's budget constraint (2) into ω_{it} and ω_{it+1} in equation (6). As before, this alteration has been done because it is important to understand at this point that taxes, which were levied on investment expenditures, only represent one of many frictions that might distort the capital Euler equation. Everything that distorts the inter-temporal savings decision of consumers, like credit-market frictions, input-financing frictions, or bubbles, is accounted for by the investment wedge.

e) Stochastic process

We assume that exogenous wedges follow a vector-autoregressive process of order 1:

$$S_{t+1} = PS_t + \varepsilon_{t+1}$$

[8] Since a closed-economy model is used in order to run the business cycle accounting exercise, the government wedge also contains the impact net exports have on the availability of domestic goods.

$$\varepsilon \sim IID(0, V)$$

Where $S_t = (\omega_{At}, \omega_{gt}, \omega_{it}, \omega_{ht})'$ is the event in time t, P the *4x4* transition matrix, and $\varepsilon_t = (\varepsilon_{At}, \varepsilon_{gt}, \varepsilon_{it}, \varepsilon_{ht})'$ are innovations that have a standard normal distribution with a mean value of zero and an unrestricted variance-covariance matrix V.[9] The transition matrix is of particular importance since it allows for spill-over effects of the wedges to each other.

4. Quantitative Analysis

Business Cycle Accounting works in different steps. First we have to obtain the values of parameters that characterize the equilibrium using calibration and structural estimation. Next, we solve the model using linear solution methods. Thirdly we elicit the wedges using data of observable variables: output, investment, consumption and labour input. Finally, we simulate the model by plugging in one wedge at a time in order to decompose the fluctuation into contributions from each wedge.

4.1 Calibration

We assume that each economy is in steady state before the crisis in 2008 and use data for this period in order to calibrate parameters. Table 3 lists the parameters that define the steady state of the economy, which are obtained through calibration.

Parameter	**Explanation**
δ	Capital depreciation rate
θ	Capital income share
Λ	Trend growth rate
β	Subjective discount factor
ψ	Time allocation parameter

Table 3. Calibrated parameters

Capital depreciation rate for each year is computed from the capital accumulation equation:

$$\delta_t = \frac{I_t}{K_t} + 1 - \frac{K_{t+1}}{K_t}$$

using annual real capital stock and investment data from the Penn World Table 8.0 during the 1990-2007 period. We convert the average annual depreciation rate and convert it to quarterly depreciation rate:

[9] Unrestricted in the sense that it allows for simultaneous correlations of innovations.

$$\delta = \frac{\delta_{1990} + \cdots + \delta_{2007}/_{18}}{4}$$

The labour share of income, $(1-\theta)$, is computed following Gollin (2002) using national income data for 2007 from *Eurostat*:.

i) Naïve labour income:

$$(1-\theta^n) = \frac{Compensation\ of\ employees}{Gross\ Domestic\ Income - taxes\ on\ production\ and\ imports\ less\ subsidies}$$

ii) Adjustment for self-employed workers:

$$(1-\theta) = (1-\theta^n)\frac{employment}{employees}$$

The trend growth rate, Λ, is directly compute as the average growth rate of total GDP over the 1995Q1 – 2007Q4 period:

$$\Lambda = \frac{log(Y_{2007q4}) - log(Y_{1995q1})}{51}.$$

The subjective discount factor, β, is calibrated to match the output-capital ratio in the steady-state Capital Euler Equation:

$$\beta = \frac{\Lambda}{\theta * \frac{y}{k} + 1 - \delta},$$

where the output-capital ratio is calibrated to match the investment-output ratio data in the steady-state capital law-of-motion:

$$\frac{y}{k} = \frac{y}{i} * (\Lambda - 1 + \delta).$$

The time allocation parameter, ψ, is calibrated to match total hours worked h data and consumption-output ratio data in the steady-state First-Order Condition of Labour:

$$\psi = \frac{1}{(1-\theta) * \frac{y}{c} * \frac{1-h}{h} + 1}.$$

We use the 2007Q4 data for investment-output ratio, consumption-output ratio, and total hours worked for the calibration. The parameter values for each country are available upon request.

4.2 Estimation

In order to estimate the stochastic process we use Bayesian Maximum Likelihood Estimation using data of output, consumption, investment and labour input over the 1995Q1 – 2007Q4 period. We resort to structural estimation because in equation (6) we can see that the investment wedge today depends on expected future values of the economy' variables in time t+1, or more precise on the investment wedge in time t+1. Structural estimation allows us to estimate the model parameters by treating the investment wedge as a latent variable.

When we conduct Bayesian estimation we need to assume a prior distribution on the parameters governing the stochastic process. We assume a diagonal transition matrix P with autocorrelation 0.9 and no spill-over and a diagonal variance-covariance matrix V with standard-deviation 0.1 and no contemporaneous correlation among innovations to wedges. However, we allow spill-over and contemporaneous correlation in the estimation. The prior and posterior distributions of each parameter for each country are available upon request.

4.3 Business Cycle Accounting Results

This section will provide an overview about the results found from BCA. First we will assess the evolution of distortions themselves. Next we will investigate the importance of each wedge on affecting the economy. Finally, we will discuss whether we can explain the relative magnitude of the wedges with respect to country-specific institutional variables.

4.3.1 Wedges

Using the Business Cycle Accounting methodology described in section 2 in order to find out what and where the distortions are, we compute the time series of the wedges from its steady state level at 2007Q4 until 2014Q4. Figure 2 shows their time path. The solid line with circular markers is the observed mean value of output. The solid line with crossed markers is the mean value of the simulated variable. The dashed line is a 95% bootstrapped confidence interval for the simulated variable. This convention is used throughout the paper.

We can see that efficiency and labour wedges are procyclical while government and investment wedges are counter-cyclical. At the beginning of the crisis the efficiency wedge begins its steep descent. At the end of the observation period it is almost 15% lower than its trend level and keeps on declining. The labour wedge jumps up slightly at the onset of the crisis, but after that it starts to fall until the beginning of 2013, where it finally levels off at around 5% below the initial level. Investment wedge initially fall but rapidly recovers and maintains above its initial level 2010. The government wedges sharply increases during 2009 reflecting the rapid growth in fiscal expenditure during the recession. The wide confidence interval during 2009 reflects the differences in the stance of the governments onto intervene.

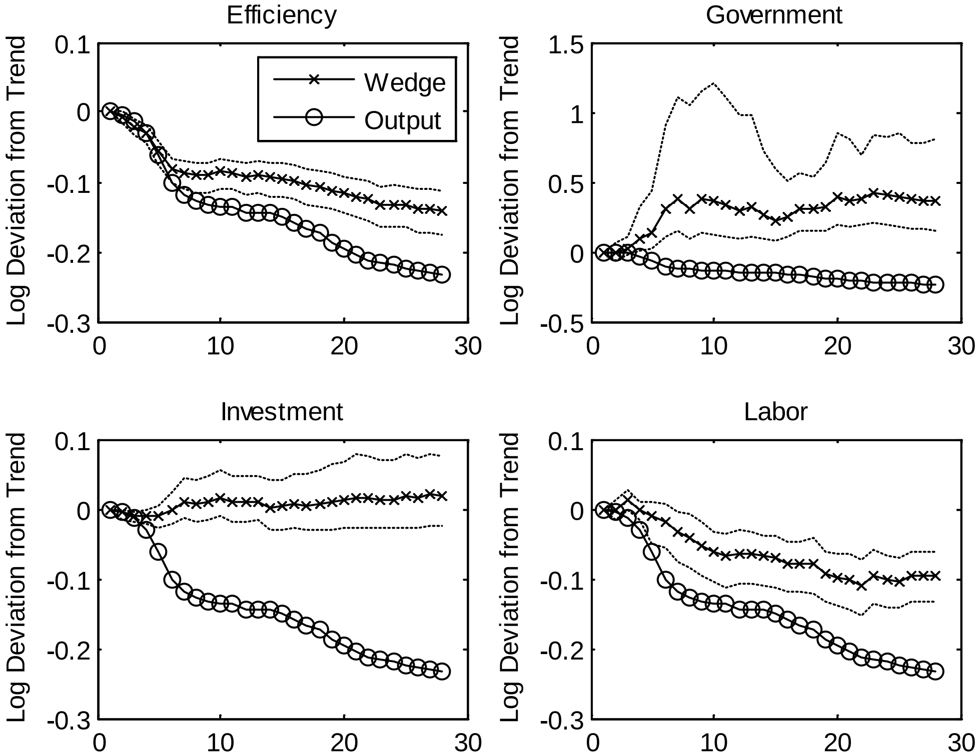

Figure 2. Time series of wedges

4.3.2 Aggregate Simulation Results

In order to assess their relative importance we need to feed the wedges, one by one, back into the prototype model and see which one has the strongest influence to the drop in output, consumption, investment and labour input. Figure 3 shows the model predictions with only one wedge compared to actual output observed. [10]

The results show that the model that most closely follows observed output performance in the after-crisis period is the efficiency wedge-alone economy. In the first year of the crisis the efficiency wedge-alone economy moves almost simultaneously with Europe's average output. After that it moves in parallel but the gap between the model's mean and observed output drop slightly widens.[11] In 2014Q4 observed output is about negative 23.5%, whereas predicted mean output is negative 20.5%. This leaves us to conclude that feeding in the efficiency wedge into the prototype model accounts for 87% of the observed output drop in Europe. Moreover, if we continue our analysis we can observe that feeding in the government wedge does not predict any output loss at all. Considering the investment wedge-alone economy we see that output is to increase slightly by about 1.5% in 2014Q4. The distortion that closes the link between the actual output drop of 23.5% and the predicted 20.5% by the efficiency wedge, is the labour-wedge model that predicts output to fall by about 4.5%. In the bottom-right picture we can see that the labour-wedge model predicts an initial constant out-

[10] By construction feeding all 4 wedges back into the model gives us simply the observed data.
[11] Note that the observed data is still contained by the 95% confidence interval.

put time path, but a fall one year after the onset of the crisis. This complements the graph on the top-left hand side. The efficiency wedge-alone economy matches output almost one-to-one in the first year after the crisis. This is because labour does not drag output down, and the efficiency wedge distorts the market by itself. Once the labour wedge also distorts output, the efficiency wedge loses its ability to perfectly predict the drop in output, and output falls even faster than predicted by this model.

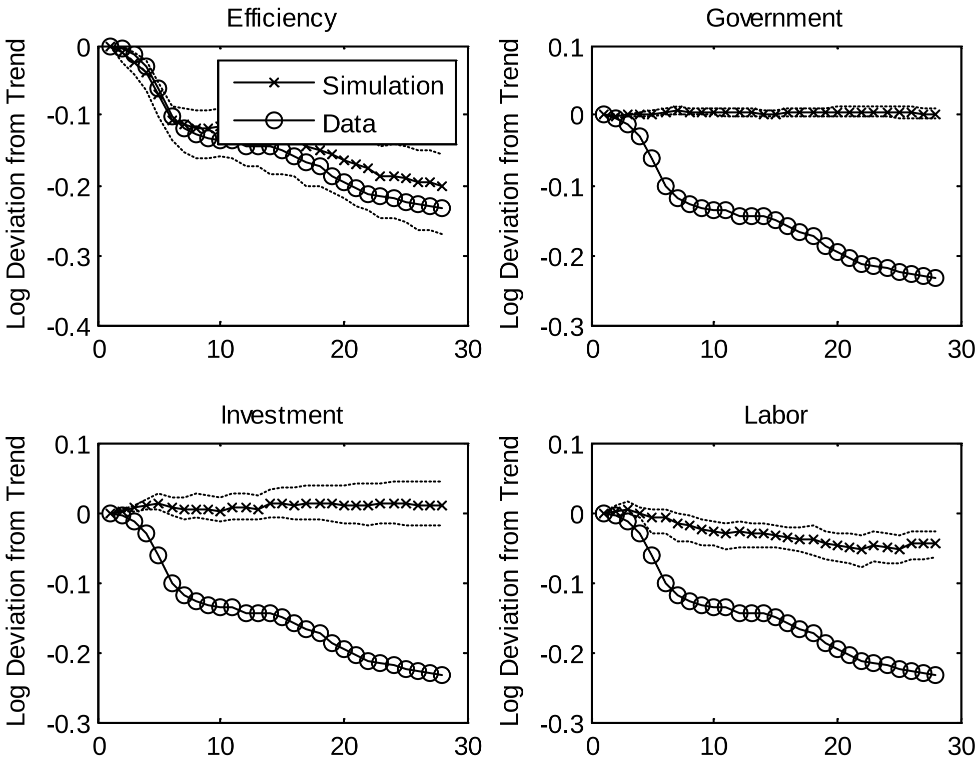

Figure 3. Simulation results - Output

Figure 4 shows us the drop in consumption through the simulated model vs. the observed consumption drop.

The results for consumption shown in Figure 4 go in parallel with the arguments of Figure 3. Even though the importance of the efficiency wedge and the labour wedge slightly change, the conclusion stays the same: the wedge that most closely resembles the drop consumption is the efficiency wedge. In 2014Q4 the efficiency wedge model predicts consumption to be negative 17% compared to an observed fall in output of negative 24%. Again, the labour wedge closes the link with predicting a drop in consumption of about 6%. As before, the models simulated with the government and the investment wedge do not predict the drop in consumption in any meaningful way.

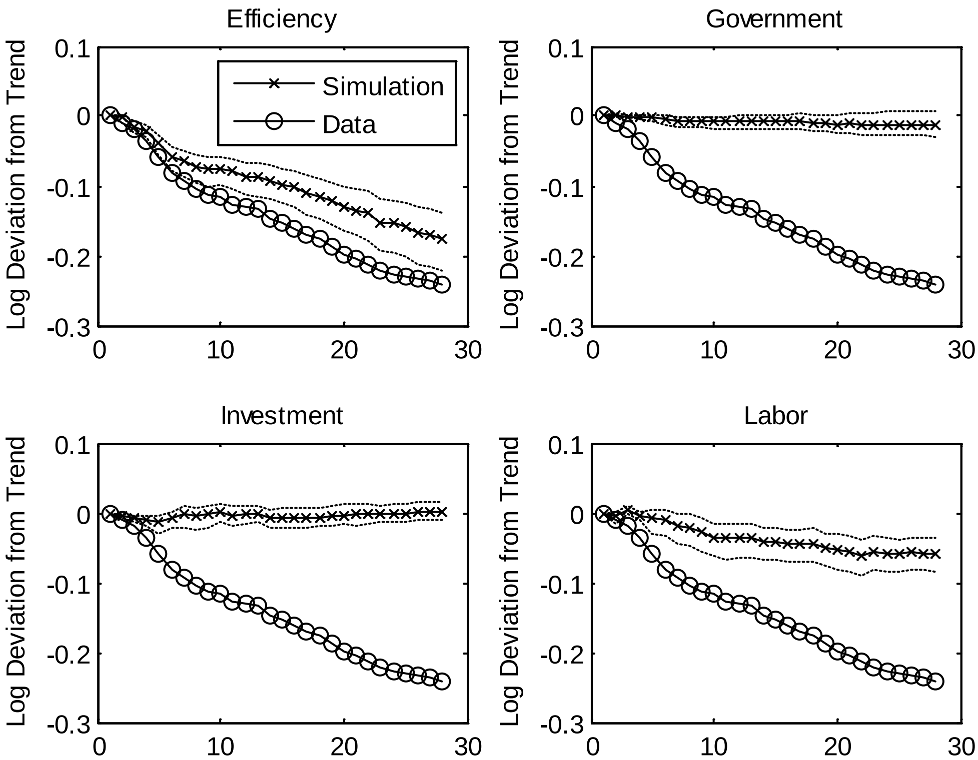

Figure 4. Simulation results – Consumption

The results for investment shown in Figure 5 emphasises the dominance of the efficiency wedge even more. We can clearly see that the efficiency-wedge model closely replicates the observed performance of investment in the past-crisis period until 2014Q4. Both the government and the labour wedge see investment slightly dropping after the crisis by about negative 5%. However, the most interesting feature here is predicted investment according to the investment wedge. The investment wedge-alone economy predicts investment to increase by about 5%, and therefore entirely fails to explain actual observed behaviour. Considering this finding and the drop in investment per capita by 45%, we can conclude that an *inter*-temporal distortion, as represented by the investment wedge, does not help to explain the drop in investment. More probably, the solution will be found in an *intra*-temporal distortion, as represented by the efficiency wedge.

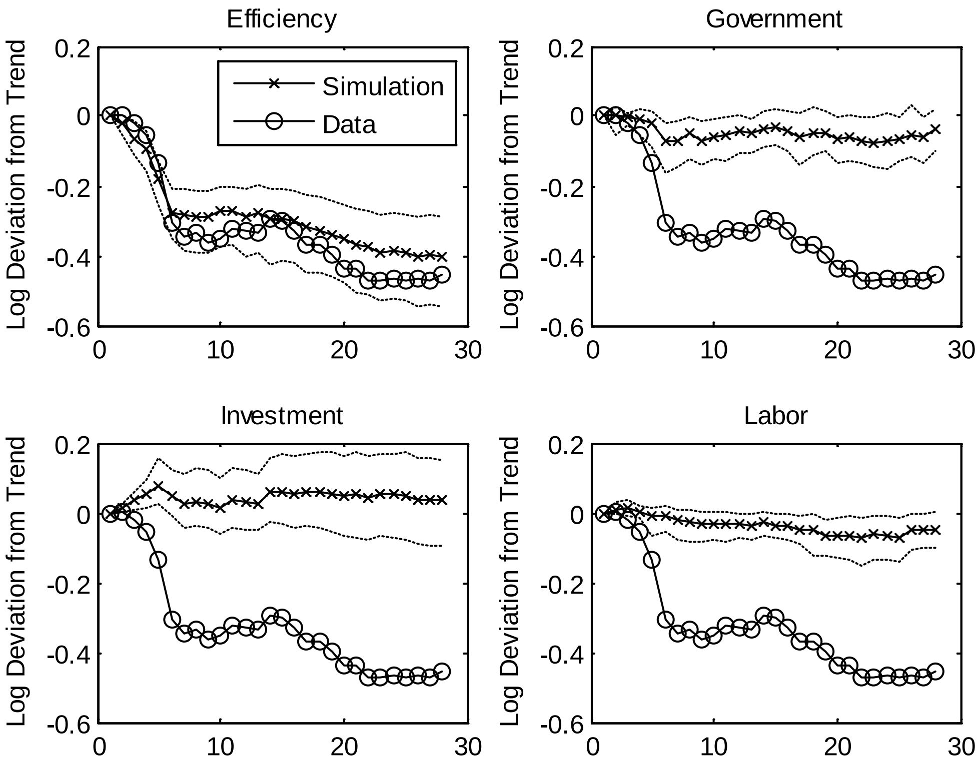

Figure 5. Simulation results – Investment

The last figure in this subsection is Figure 6 and shows us the predicted and the observed time path of labour from 2007Q4 until 2014Q4.

This analysis draws a different picture than the simulations before. The conclusion of figure 6 is that the efficiency wedge plays only a secondary role in explaining the drop in labour during and after the crisis. The efficiency wedge-alone model predicts a drop of about negative 4% in labour after the beginning of the crisis, but levels off at around negative 2.5% until the end of the observation period. The government and the investment wedge again misinterpret the past-crisis behaviour of labour and predict an increase of around 1.2% and 1.1%, respectively. Here the labour wedge prediction, except for the time between 2009 and the beginning of 2011, exactly replicates the observed data in labour input. At the end of the observation period in 2014Q4 more than 96% of the observed data in labour is explained by the prototype model where the labour wedge is the only exogenous variable.

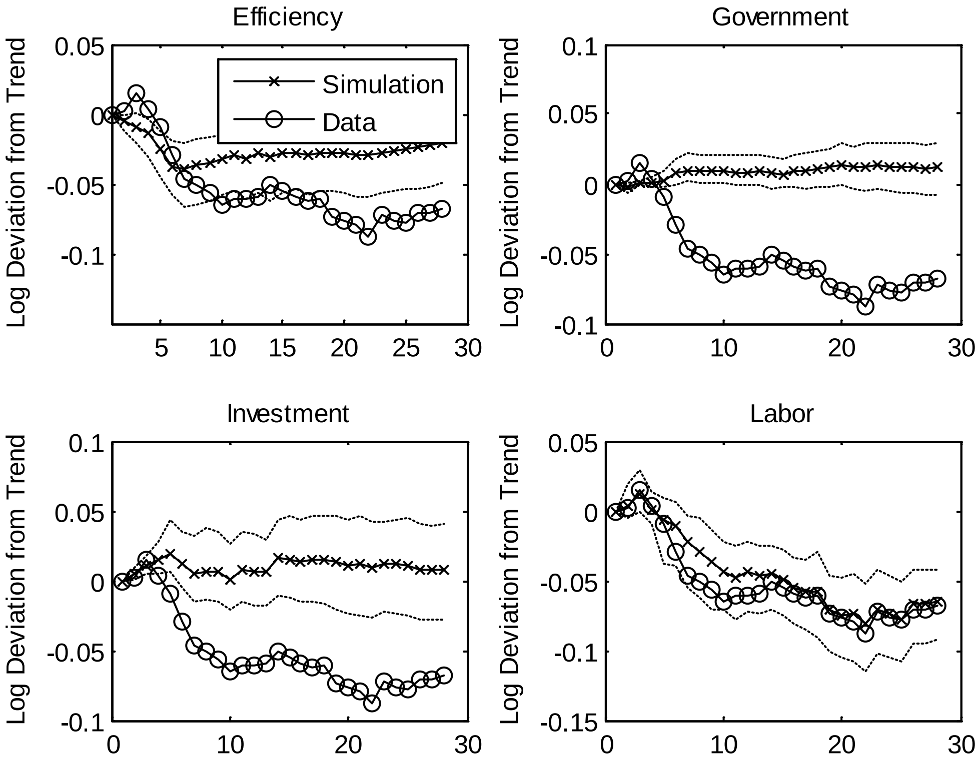

Figure 6. Simulation results – Labour

4.3.3 Country Specific Simulation Results

In this section we want to consider country specific results. Table 4 shows the loss in output for each country individually. In addition, the last four columns represent the relative importance of the wedges with respect to country-specific downturns[12]:

Country	**Output Loss - 2007Q4-2014Q4**	**Wedge Contribution**			
		ω_A	ω_g	ω_i	ω_h
Austria	-14.89%	80.81%	-1.12%	14.46%	5.85%
Belgium	-13.47%	137.85%	7.10%	-26.63%	-18.32%
Cyprus	-36.00%	36.35%	5.44%	50.92%	7.29%
Estonia	-50.69%	88.54%	3.06%	-0.33%	8.74%
Finland	-34.28%	134.10%	5.47%	-38.12%	-1.46%
France	-12.07%	77.70%	2.20%	-2.23%	22.33%
Greece	-48.87%	95.58%	-2.31%	-21.01%	27.73%
Germany	-5.62%	140.49%	-2.91%	-31.52%	-6.06%

[12] Country specific post-crisis behaviour with respect to consumption, investment, and labour input plus the relative importance of the wedges towards these variables are available upon request.

Ireland	-30.95%	36.66%	2.20%	29.82%	31.32%
Italy	-19.52%	96.04%	-4.24%	-39.42%	47.62%
Latvia	-53.38%	134.67%	-0.99%	-49.37%	15.69%
Luxembourg	-29.19%	97.52%	-5.58%	8.69%	-0.63%
Malta	0.49%	216.97%	-180.65%	623.90%	-560.22%
Netherlands	-21.07%	127.43%	2.33%	-71.45%	41.69%
Portugal	-19.53%	60.96%	-17.05%	-9.16%	65.26%
Slovakia	-20.81%	117.48%	0.47%	-49.43%	31.48%
Slovenia	-30.82%	58.04%	-0.38%	35.85%	6.50%
Spain	-23.32%	29.91%	-13.80%	39.97%	43.92%
Czech Republic	-20.19%	134.50%	0.18%	-50.98%	16.30%
Denmark	-21.64%	32.69%	9.65%	48.95%	8.71%
Hungary	-21.72%	53.19%	1.83%	44.07%	0.91%
Lithuania	-37.24%	85.86%	2.36%	0.61%	11.17%
Poland	-5.81%	82.40%	1.96%	4.03%	11.61%
Romania	-7.55%	58.08%	-57.20%	11.18%	87.95%
Sweden	-18.34%	108.27%	5.31%	-12.13%	-1.45%
United Kingdom	-17.35%	110.48%	5.11%	-27.42%	11.82%
Norway	-19.12%	107.74%	12.36%	-0.96%	-19.14%
Iceland	-29.25%	63.90%	-11.13%	3.28%	43.95%

Table 4. Country-specific post-crisis behaviour

Out of the 28 European countries considered in this study, the first 18, Austria up to Spain, are the countries that adapted the Euro as their legal tender by the end of 2014. The following eight countries, Czech Republic up to the United Kingdom, belong, like the 18 afore mentioned countries, to the European Union, but did not adopt the Euro currency as their official medium of exchange. Norway and Switzerland, the two countries at the end of the list, belong to Europe, but neither accepted the Euro as their currency, nor did they join the European Union.

The second column gives us the output loss for the time from the onset of the crisis until 2014Q14[13]. First of all, one thing to note here is that the only country that seems to have recovered from the crisis is Malta with a past-crisis output performance of positive 0.49%. All other countries have not come back to their pre-crisis trend level. Countries which seem to suffer the most are Latvia, Estonia, Greece, Lithuania, Cyprus, and Finland, with a loss of negative 53%, 51%, 49%, 37%, 36%, and 34%, respectively. Countries with an output loss more than negative 30% sum up to 10 (when including Luxembourg as being on the margin). Countries with an output loss more than negative 20% amount to 19 (including marginal countries like Italy, Portugal, and Norway). This concludes that almost 68% of economies in our sample are negative 20% worse-off than before the crisis.

[13] Since for Luxembourg it was not possible to obtain reliable data for 2014Q4, we consider the final period to compute the loss in output to be 2014Q3.

The main picture we get from the country specific BCA analysis is that indeed the efficiency wedge is the most important wedge explaining the drop in observed post-crisis European output. The observed output drop in Belgium, Estonia, Finland, Germany, Luxembourg, in the Czech Republic, Sweden, in the United Kingdom, and in Norway can almost exclusively be explained by the efficiency wedge.

However, some countries do not fit this pattern. For Cyprus, Malta and Denmark the wedge that drives the downturn in output is, surprisingly, the investment wedge. In all three countries the efficiency wedge comes at second place, whereas the labour and investment wedges do not play an important role at all. In Spain, efficiency wedge has a slightly smaller contribution to the output loss relative to that of investment and labour wedges.

It is important to mention that some countries are simulated with a stochastic process estimated with a short data period.[14] In order to check whether the results are affected by the short estimation period, we simulate these countries twice. The first time we use the estimated transition matrix and compute the relative importance of the wedges. The second time we use a prior specified transition matrix with a diagonal of 0.9, and a prior specified variance-covariance matrix with a diagonal of 0.01. In most of the cases the relative importance of the wedges does not change. Even in the cases where the ranking of the importance does, the most important wedge does not lose its major contribution to output fluctuation.

In the next subsection we want to find out whether there might be country-specific variables that explain the importance of the efficiency wedge.

4.4 Regression Analysis

In this section we want to examine whether we can find exogenous variables that have explanatory power with respect to the idiosyncrasies in the BCA results using simple cross-sectional Linear Regression Models. [15] First, we investigate the absolute change of the efficiency wedge from 2007Q4 to 2014Q4:

$$\omega A_i = \alpha + \beta_z * x_{z,i} + \varepsilon_i \qquad (10)$$

$$\varepsilon_i \sim N(0, \sigma^2)$$

Where i is the number of countries[16] in the model and z is the number of exogenous variables x. ωA_i is the change in the time path of the efficiency wedge[17] from 2007Q4 up to 2014Q4 for country i. The error term, ε, is country specific and normally distributed with a variance of σ^2.

(11)

[14] Countries that lack specific data coverage from 1995Q1 onwards are: Belgium, Estonia, Ireland, Latvia, Luxembourg, Iceland, Malta, Slovakia, Czech Republic, Hungary and Poland. For particular starting dates see *2. Data*. Note that among them Belgium, Ireland, Slovakia and Czech Republic where not estimated a second time since their data coverage was sufficient in order to be reliable.

[15] Both regressions are computed with robust standard errors through a heteroscedasticity consistent covariance matrix.

[16] Since Malta is a clear outlier in our dataset we have to drop it for our regression analysis. Therefore we end up with 27 countries.

[17] The time path of the efficiency wedge can also be called *Total Factor Productivity*. For clarity see 2.1.3 a).

Secondly, we investigate the relative importance of the efficiency wedge towards the loss in output. We do this by of the form:

$$y_i^{\omega A} = \alpha + \beta_z * x_{z,i} + \varepsilon_i$$

$$\varepsilon_i \sim N(0, \sigma^2)$$

Where the interpretation for i, z, x and ε are the same as before. $y_i^{\omega A}$ is the relative importance of the efficiency wedge towards the loss in output for country i and is assumed to be endogenous.

4.4.1 Variables

To get an idea about the dominance of the efficiency wedge we collect 14 exogenous variables which can potentially explain the resulting importance of this distortion. The set of variables can be subdivided into three different groups.

The first group contains variables that relate to the economic performance of every country before and after the crisis:

- *output_loss:* as a measure of the lost output per capita from the onset of the crisis until 2014Q4.
- *y_size:* as a measure of the size of the economy, in per capita terms at 2007Q4.
- *pop:* size of the population at time 2007Q4.
- *realgdpgrowthpercapita:* the average annual growth rate of GDP per capita from 1995 to 2007.
- *tradetogdp*: the total trade to GDP ratio
- *cpi:* Consumer price index average annual inflation rate
- *employinpublicsector*: employment in the public sector, as percentage of total employment
- *totalgovdebt*: total general government debt to GDP ratio
- *bankingsectorassets*: banking sector asset to GDP ratio

In the second group we collect two variables that are meant to capture EU-specific characteristics:

- *eu:* a dummy determining whether a country belongs to the European Union on the last quarter of 2014.
- *currency:* a dummy explaining whether a country adopted the Euro currency as their legal tender by the last quarter of 2014.

The third group contains variables taken from the *IMD World Competitiveness Yearbook 2014* database:

- *diversification:* diversification of the economy (industries, export markets, etc.) is limited (1) or extensive (10)
- *stateownedenterprises*: state ownership of enterprises is a threat to business activities (1) or is not a threat to business activities (10)
- *labourregulations*: Labour regulations (hiring/firing practices, minimum wages, etc.) hinder business activities (1) or do not hinder business activities (10)

For the first regression model, equation (10), we use the *IMD* variables computed as the change between 2007 and 2014. In the second regression model, equation (11), we use the same variables but in levels, computed as the average value from 2007 until 2014.

4.4.2 Regression Results

To find meaningful regression models we work in two different steps. The first step in order to determine the importance of the explanatory variables is to implement a *Backwards-Stepwise-Selection* approach by Hendry (1983). Hereby we assume an initially general model and cut down insignificant variables one by one. The ultimate aim of this exercise is to end up with variables that significantly explain a robust relationship between the dependent and independent variables.

The second step entails a *Stepwise-Forward-Selection* approach. Starting with a model explained only by a constant term, we begin by successively adding the variables with the lowest p-values until no significant information is left.

4.4.2.1 Absolute change in the efficiency wedge[18]

Using the *Backwards-Stepwise-Selection* approach we start with the regression model in Table 5:

Dependent Variable: OMEGAATIMESERIES_END
Method: Least Squares
Date: 04/28/15 Time: 16:57
Sample: 1 27
Included observations: 24
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.777760	0.279022	2.787454	0.0164
BANKINGSECTORASSETS	-0.000347	0.000251	-1.385407	0.1911
CPI	0.010415	0.006990	1.489931	0.1621
CURRENCY	-0.009444	0.030317	-0.311501	0.7608
EMPLOYINPUBLICSECTOR	0.006850	0.004952	1.383270	0.1918
EU	-0.063301	0.061268	-1.033187	0.3219
LABOURREGULATIONS	-0.016004	0.016424	-0.974426	0.3491
REALGDPGROWTHPERCAPITA	-0.053039	0.015050	-3.524128	0.0042
STATEOWNEDENTERPRISES	0.027945	0.013396	2.086039	0.0590
TOTALGOVDEBT	0.000577	0.000811	0.711310	0.4905
TRADETOGDP	0.002986	0.003647	0.818885	0.4288
Y_SIZE	-0.081028	0.024787	-3.268959	0.0067

R-squared	0.771501	Mean dependent var	-0.152395
Adjusted R-squared	0.562044	S.D. dependent var	0.092082
S.E. of regression	0.060938	Akaike info criterion	-2.451053

[18] Since including the variable explaining the loss in output leads to endogeneity in this regression model, we omit it. Variables which show a high degree multicollinearity with several regressors, and are therefore omitted, are the variables *diversification* and *pop*. This results in only 11 possible explanatory variables contained by the model, as compared to 14 in *5.3.2.2 Relative importance of the efficiency wedge*.

Sum squared resid	0.044562	Schwarz criterion	-1.862026
Log likelihood	41.41263	Hannan-Quinn criter.	-2.294784
F-statistic	3.683336	Durbin-Watson stat	2.372542
Prob(F-statistic)	0.017022	Wald F-statistic	7.895861
Prob(Wald F-statistic)	0.000618		

Table 5. Regression model #2 – full model

After cutting down all the insignificant variables we end up with the final regression in Table 6. Following the *Stepwise-Forward-Selection of Variables* approach we arrive at the same regression model than the one in Table 6.

Dependent Variable: OMEGAATIMESERIES_END
Method: Least Squares
Date: 04/28/15 Time: 16:55
Sample: 1 27
Included observations: 26
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.034984	0.019055	-1.835907	0.0799
REALGDPGROWTHPERCAPITA	-0.045929	0.007748	-5.927846	0.0000
STATEOWNEDENTERPRISES	0.020284	0.009712	2.088670	0.0485
TRADETOGDP	0.004592	0.001856	2.474189	0.0215

R-squared	0.546751	Mean dependent var	-0.152406
Adjusted R-squared	0.484944	S.D. dependent var	0.088325
S.E. of regression	0.063388	Akaike info criterion	-2.538438
Sum squared resid	0.088398	Schwarz criterion	-2.344884
Log likelihood	36.99969	Hannan-Quinn criter.	-2.482701
F-statistic	8.846130	Durbin-Watson stat	1.696293
Prob(F-statistic)	0.000490	Wald F-statistic	21.57162
Prob(Wald F-statistic)	0.000001		

Table 6. Regression model #2 – final model

The regression in Table 6 shows us that the variables *realgdpgrowthpercapita*, *stateownedenterprises* and *tradetogdp* are individually and jointly significant, and, except for the variable *realgdpgrowthpercapita*, positively correlated with the endogenous variable. This implies that a country with a higher annual pre-crisis growth rate of real GDP per capita, measured as the average growth rate between 1995 and 2007, by 1 percentage point will experience a 0.046 percentage point larger drop in efficiency wedges. Considering the variable *stateownedenterprises* which is a proxy and tells us whether state ownership of enterprises is a threat to business activities. This variable is computed as the change in the index between 2007 and 2014. Since this variable is an index number, it is important to note that the coefficient value does not have a meaning. The importance lies in the sign of the coefficient, and whether the variable is statistically significant. We can conclude that a country in which the government ownership of businesses becomes less threating towards business activities will experience a smaller drop in efficiency wedges. Finally the variable *tradetogdp* which is the change in the ratio between the average of exports plus imports divided by the country's GDP. This variable is again computed as the change over the 2007 – 2014 period. The results show that a country with an increasing trade to GDP ratio by 1 percentage point will experience a smaller drop in efficiency wedges by 0.0046 percentage points.

4.4.2.2 Relative importance of the efficiency wedge, $y_i^{\omega A}$

Again using the *Backwards-Stepwise-Selection* approach we start with the regression model in table (11):[19]

Table 7. Regression model #1 – full model

Dependent Variable: CONTRIB_WA_ENDOGENOUS
Method: Least Squares
Date: 04/29/15 Time: 08:24
Sample: 1 27
Included observations: 24
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.720117	5.375326	-0.133967	0.8961
BANKINGSECTORASSETS	4.32E-05	0.000955	0.045174	0.9649
CPI	-0.070828	0.173160	-0.409030	0.6911
CURRENCY	0.127196	0.303783	0.418708	0.6843
DIVERSIFICATION	0.114486	0.158085	0.724206	0.4855
EMPLOYINPUBLICSECTOR	-0.004220	0.027246	-0.154874	0.8800
EU	-1.635924	1.538608	-1.063249	0.3127
OUTPUT_LOSS	-2.695269	1.967841	-1.369658	0.2008
POP	0.254383	0.194091	1.310641	0.2193
REALGDPGROWTHPERCAPITA	-0.092267	0.207637	-0.444367	0.6662
STATEOWNEDENTERPRISES	0.136113	0.129488	1.051166	0.3179
TOTALGOVDEBT	-0.003448	0.006352	-0.542783	0.5992
TRADETOGDP	0.008107	0.006377	1.271312	0.2324
Y_SIZE	-0.303298	0.529796	-0.572480	0.5796

R-squared	0.276970	Mean dependent var	0.881550
Adjusted R-squared	-0.662970	S.D. dependent var	0.344428
S.E. of regression	0.444162	Akaike info criterion	1.505941
Sum squared resid	1.972795	Schwarz criterion	2.193139
Log likelihood	-4.071295	Hannan-Quinn criter.	1.688255
F-statistic	0.294667	Durbin-Watson stat	2.278177
Prob(F-statistic)	0.978767	Wald F-statistic	2.456625
Prob(Wald F-statistic)	0.080342		

Cutting down insignificant variables, one at a time, we end up with the regression model that only consists of an intercept term and no exogenous variables. This is because prior seemingly significant variables become insignificant once insignificant ones are taken out of the model.

[19] Due to high correlation to other variables, the variable *labourregulations* is taken out of the regression model.

This finding is confirmed through the *Stepwise-Forward-Selection of Variables* approach. By adding the variable with the smallest p-value into the model, we find that none of the individual variables are remotely close to a significance level of 10%.

This leads us to the conclusion that none of the variables considered in this model have statistical significance in explaining why the efficiency wedge in one country takes on a more relative importance towards the loss in output than in another.

Summarising section *5.3 Regression Model*, we see that out of 11 variables that are potentially explanatory towards the level of the efficiency wedge, or *Total Factor Productivity*, in 2014Q4, only the variables capturing the pre-crisis real GDP per capita growth rate, the change in the variable that observes whether state intervention in companies is harmful to economic activity and the change in the trade to GDP ratio are seemingly significant. Except for the pre-crisis real GDP per capita growth rate, all variables are positively correlated with the level in Total Factor Productivity in 2014Q4.

Considering the regression model with the relative importance of the efficiency wedge towards the loss in output as endogenous variable, we find that through both approaches, the *Backwards-Stepwise-Selection* and the *Stepwise-Forward-Selection* approach, none of the explanatory variables seem to be significant. From this it follows that other variables than the ones used in this study must be found in order to explain why the efficiency wedge plays a more important role in some countries than in others.

5. Conclusion

In this paper we reviewed the European economic experience from the onset of the Great Recession in early 2008 until the end of 2014. Instead of only focusing on aggregate behaviour, we decomposed Europe into 28 individual economies and focused on crisis and past-crisis behaviour of economic variables like output, consumption, investment and labour input. We found that the drop in Total Factor Productivity accounts for almost 87% in the fall in output. In respect to consumption and investment, Total Factor Productivity answers for 70 and 90%, respectively. The fall in Labour input, however, can only partially explained by TFP. Here the distortion between the Marginal Rate of Substitution between consumption and leisure today, and the Marginal Product of Labour, accounts for more than 96%. This leads us to conclude that researchers, focusing on the detailed propagation mechanism leading to the fall in output during the Great Recession, find their answer in channels distorting the Total Factor Productivity measure of countries.

Furthermore we saw that the decline in the efficiency wedge can be explained by exogenous variables used in this study. We found significant effects of the pre-crisis per capita real GDP growth rate, the change in the variable that observes whether state intervention in companies is harmful to economic activity and the trade to GDP ratio on the decline in the efficiency wedge. By contrast, the relative importance of the efficiency wedge towards the loss in output cannot be explained by any of the independent variables tested in this paper. Future research should focus on why efficiency deteriorated after the onset of the Great Recession and has not recovered by the end of 2014.

References

To be added