University of Kent

School of Economics Discussion Papers

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

Florian Gerth and Keisuke Otsu

September 2016

KDPE 1606

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

Florian Gerth† Keisuke Otsu‡

September 6, 2016

Abstract

This paper analyses the Post-crisis slump in 29 European economies during the 2008Q1 - 2014Q4 period using the Business Cycle Accounting (BCA) method á 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. Moreover, we find that the growth rate of non-performing loans are negatively associated with the decline in efficiency wedges. These findings support the emerging literature on resource misallocation triggered by financial crises.

Keywords: Great Recession in Europe, Business Cycle Accounting
JEL Code: E13, E32

*We are grateful to Sylvain Barde, Pedro Brinca, Jagjit Chadha, Patrick Minford, Claudio Morana, Jakub Muck, and participants of the MaGHiC PhD workshop at the University of Kent, the 47th Money Macro and Finance Research Group Annual Conference, and the Society for Computational Economics 22nd International Conference Computing in Economics and Finance for their helpful comments.

†School of Economics, University of Kent, Canterbury, Kent, CT2 7NP, United Kingdom. Email: F.Gerth@kent.ac.uk , Tel. +44-1227-824437.

‡School of Economics and MaGHiC, University of Kent, Canterbury, Kent, CT2 7NP, United Kingdom. Email: K.Otsu@kent.ac.uk , Tel. +44-1227-827305.

Non-technical summary

Nearly a decade has passed since the onset of the Great Recession. However, European countries have shown very little recovery. Economists collectively agree that the financial market turmoil initiated by the subprime loan crisis in the US is the source of the Great Recession. However, there is little consensus about the propagation mechanism through which the initial shock led to a steep and persistent drop in key economic variables. In order to shed light on this issue, this paper analyses the Great Recession in 29 European countries over the 2008Q1-2014Q4 period with the Business Cycle Accounting methodology á la Chari, Kehoe and McGrattan (2007). This method evaluates the importance of different distortions during the Great Recession within a Dynamic Stochastic General Equilibrium framework. These distortions, also called wedges, help us find the propagation mechanism of shocks driving the post-crisis slump in Europe.

The business cycle accounting method is conducted as follows. First, we define a model with time varying production efficiency, labor market distortions, investment market distortions, and government expenditure, which we define as efficiency, labor, investment and government wedges. Next, we use the data of output, consumption, investment and labor in order to elicit the wedges. Finally, we plug the computed wedge one-by-one into the model in order to assess the impact of each wedge on business cycles.

Business cycle accounting provides equivalence and accounting results. Equivalence results show that a wide class of macroeconomic models can be mapped into the prototype business cycle accounting model with wedges. The accounting results provide quantitative indication on which wedge has the highest explanatory power of the business cycle fluctuation. Together, the two results guide the researcher to understand the main forces that drive the business cycle episode of interest.

The key result is that the deterioration in the efficiency wedge is the most important channel in accounting for the post-crisis decline in European output. This is consistent with the literature that blames the misallocation effect of credit crunches for aggregate productivity loss. We further find that countries with rapid growth in non-performing loans experienced less deterioration in efficiency wedges. This is consistent with the literature that argues that evergreen loans to unproductive zombie firms deteriorates the firm entry-exit economic metabolism and reduces aggregate production efficiency in the economy.

1 Introduction

While more than seven years has passed since the onset of the Great Recession, European countries have not shown any signs of recovery. Moreover, there is few consensus on why this is the case. This paper quantitatively analyses the post-crisis slump in Europe from the beginning of 2008 until the end of 2014 with the Business Cycle Accounting (BCA) method á la Chari, Kehoe and McGrattan (2007).

BCA is a useful tool to decompose business cycle fluctuations into their contributing factors. The idea behind this approach is to lead researchers into the direction of classes of economic models that give detailed understanding behind economic (mis)performances. The accounting procedure is conducted as follows. First, several exogenous frictions called wedges are defined in equilibrium conditions of a standard Real Business Cycle model. Second, the stochastic process of these wedges are structurally estimated using Bayesian estimation methods. Third, the wedges are backed out using data and the model solution. Finally, the wedges are put back into the model, one by one, in order to quantify their relative importance over the drop in output, consumption, investment, and labor.

The BCA method has been widely applied to the analysis of specific business cycles episodes in various countries. Chari, Kehoe and McGrattan (2007) focus on the Great Depression and early 1980s recession in the U.S. Saijo (2008) investigates the Great Depression in Japan. Klein and Otsu (2013) compares the interwar Great Depressions in the U.S. and Western Europe. Kersting (2008) studies the UK recession in the 1980s. Kobayashi and Inaba (2006) studies the Great Depression and lost decade in Japan. Chakraborty (2009) investigates 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 (2010a) studies the 1998 crises in East Asia. Cho and Doblas Madrid (2013) compare 23 financial crisis episodes over the 1980-2001 period. Chakraborty and Otsu (2013) analyze the growth episodes of the BRICS economies. Brinca (2014) studies 22 OECD countries over the 1970-2011 period. Most of these studies show that efficiency and labor wedges are important in accounting for output fluctuations.

The outbreak of the 2008 financial crisis led to a rash of research on the nature of financial crises in quantitative macroeconomic models. Khan and Thomas (2013) and Buera and Moll (2015) construct models with heterogeneous firm level productivity in which credit shocks to borrowing constraints lead to misallocation of production factors across firms. Gertler and Kiyotaki (2010), Gertler and Karadi (2011) and Gertler, Kiyotaki and Queralto (2012) construct models with financial frictions in the banking sector which constrains investment. Jermann and Quadrini (2012) constructs a model with a working capital constraint on employment where an increase in the firms borrowing cost increases the cost of labor. These models, through the lens of business cycle accounting, can be mapped into prototype models with efficiency, investment and labor wedges. We can therefore use our business cycle accounting results to infer the channel through which the financial crises have operated.

Our paper is closely related to Brinca, Chari, Kehoe and McGrattan (2016) which focuses on the Great Recession in 24 OECD countries. While they investigate the behavior of wedges and decompose the decline in output between the respective peak and troughs, we focus on the slow recovery of 29 European countries and investigate the economic performance during the 2007Q4-2014Q4 period. The model parameters are calibrated and estimated to the data over the 1995Q1 - 2007Q4 period for every country individually. Secondly, by simulating the model over the 2008Q1 - 2014Q4 period we analyze not only the cross-country differences of the impact of the crisis, but also of the recovery from the crisis. This enables us to assess the linkages of economic fundamentals to wedges responsible for the post-crisis slump in European countries.

The main findings of this paper are that the distortion in the representative firm's production function (the efficiency wedge) is mainly responsible for the prevalent output decline in Europe beginning at the onset of the crisis in the early 2008. This is consistent with the literature that blames the misallocation effect of credit crunches for aggregate productivity loss. The exception to this result is Southern Europe in which investment wedges and labor wedges play more important roles. We further find that a subset of financial variables is significantly related to the cross-country differences in the magnitude in the wedge distortions. Countries with high growth in non-performing loans relative to total loans experienced less deterioration in efficiency wedges but greater deterioration in investment wedges. Also, countries with less decline in the housing price index experienced less deterioration in labor wedges.

The remaining of this paper is structured as follows: The second section describes the data. The third section introduces the BCA model. The fourth section presents the quantitative analysis. In section 5 we discuss possible

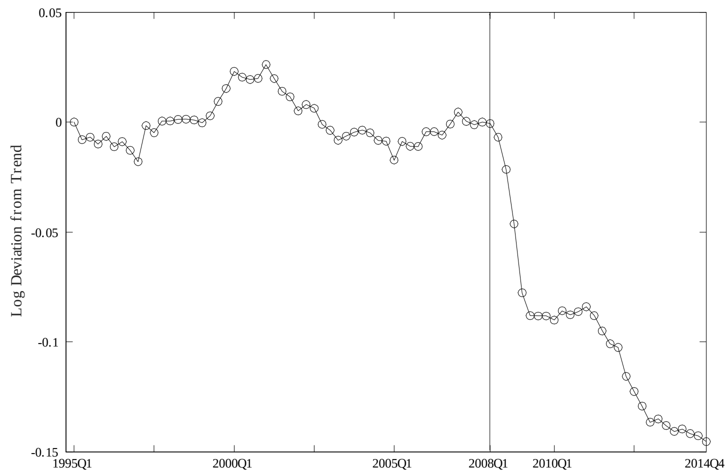

Figure 1: Detrended Aggregate European Output per Adult

variables that commove with predicted output performances. The last section concludes.

2 Data

Figure 1 presents the aggregate quarterly per capita GDP in 29 European countries over the 1995Q1-2014Q4 period detrended by the average growth rate over the 1995Q1-2007Q4 period. The figure clearly shows the devastating impact of the financial crisis on European GDP in 2008. Moreover, the economy is showing no sign of recovery with a double dip in early 2010s.

The countries in our sample are listed in Table 1.[1] We also report the detrended output decline between 2007Q4 and 2014Q4 for each country in percentage points. Clearly, some countries experienced greater declines in per capita output than others. In the following we look into country specific data in order to compare the experiences of each country.

[1] Full data is not available for Bulgaria and Croatia.

Table 1: Sample Countries and Output Drop

Euro Area:					
Austria	14.9	Belgium	13.5	Cyprus	36.0
Estonia	50.7	Finland	34.3	France	12.1
Germany	5.6	Greece	48.9	Ireland	30.9
Italy	19.5	Latvia	53.4	Luxembourg	26.0
Malta	-0.5	Netherlands	21.1	Portugal	19.5
Slovakia	20.8	Slovenia	30.8	Spain	23.3
European Union: Euro Area plus					
Czech Republic	20.2	Denmark	21.6	Hungary	21.7
Lithuania	37.2	Poland	5.8	Romania	7.5
Sweden	18.3	United Kingdom	16.6		
Europe: European Union plus					
Iceland	29.3	Norway	19.1	Switzerland	8.9

Quarterly data for output, consumption, investment, labor hours (as a measure for labor input), employment, weekly working hours, adult population above 15 years old is obtained through Eurostat, using the European System of Accounts (ESA) 2010 data. The data coverage goes from 1995Q1 up to 2014Q4. The expenditure data for output, consumption and investment are obtained in real terms. For periods in which ESA 2010 expenditure data is missing, the series is extrapolated using the ESA 2005 expenditure data. For periods in which ESA 2010 total hours data is missing, ESA 2005 data is used whenever possible. If neither quarterly total hours worked exists in the ESA 2010 nor in the ESA 2005 data set, quarterly total hours worked was computed as:

$$\begin{aligned}\text{quarterly total hours worked} &= \text{weekly hours worked} \times \text{weeks per quarter} \\ &\quad \times \text{quarterly employment},\end{aligned}$$

where the amount of weeks worked per quarter is set at 12. In order to obtain adult population, we subtract population younger than 15 years from the total population. When population younger than 15 years is not available in quarterly terms, we interpolate the annual value.

Private consumption expenditure in the data consists of expenditure on non-durable goods, semi-durable goods, durable goods, and services. We construct private consumption expenditure as the sum of expenditure on non-durable goods, semi-durable goods, and services. Durable goods expenditures are added to private investment expenditures. Our measure of total investment contains private investment, expenditures on durable goods, and public investment expenditures by the government. In cases where the ESA 2010 data set does not allow the division between the different consumption values, we use total private consumption expenditure and gross capital formation as a measure for consumption and investment, respectively, in the estimation and simulation process.[2]

In order to define a stationary economy, all variables are detrended by their respective growth trends:

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

where Y_t is total output, C_t is consumption, I_t is investment, H_t is labor input, N_t is the level of adult population growing at the rate $(1+n)$, and Γ_t is the level of labor augmenting technical progress growing at the rate $(1+\gamma)$, which we proxy with the average per adult output growth rate.[3]

Figure 2 shows the cross-country mean of the time series of output y, consumption c, investment i, and labor input h from 2007Q4 (the last period before the onset of the crisis) until 2014Q4. The solid line with circular markers is the observed mean value of the data variable, the dashed line represents the 95% bootstrap confidence interval.

Notice that the post crisis decline in output is considerably larger than the aggregate output decline in Figure 1. This indicates that there are several small countries with large per capita output drops. For convenience we will use the simple mean figures throughout this paper.

We can clearly see that output and consumption start a rapid decline in

[2] Countries where the division of consumption and investment was not possible are: Belgium, Hungary, Iceland, Ireland, and Romania. Regarding the investment measure for Belgium, data of investment expenditures is missing for the 2011Q2-2014Q4 period in the Eurostat database. Therefore, we computed the investment-output ratio from the OECD Economic Outlook tables and multiplied it with total output obtained from the ESA 2010 dataset.

[3] By definition the growth rate of per capita output must be equal to the growth rate of labor augmenting technical progress along the balanced growth path. Total hours worked is only detrended by dividing through per adult population, since its only trend comes from the growth in population and not from the growth in labor augmenting technical progress.

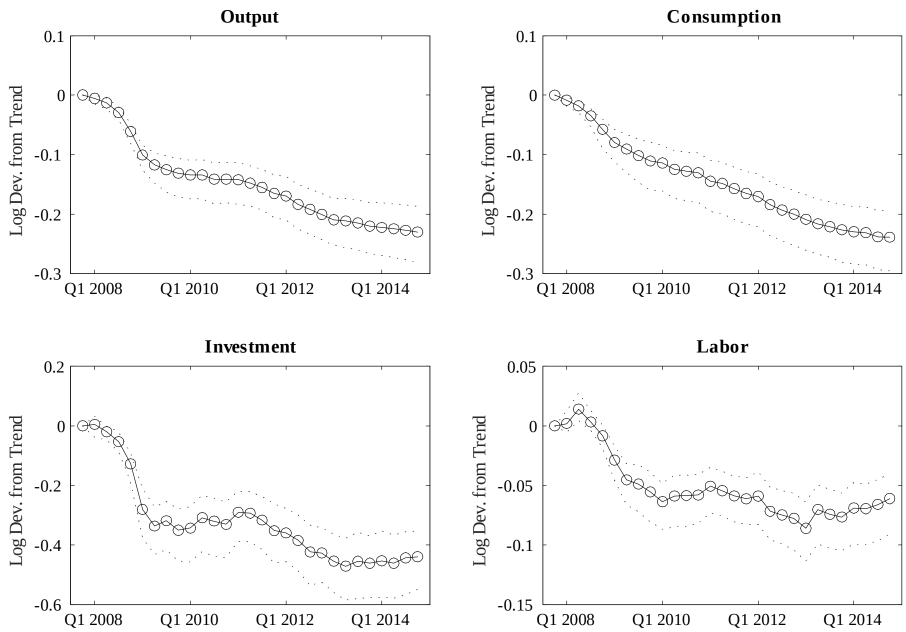

Figure 2: Detrended Average European Data

the first few quarters of the crisis. This decline continues until the end of the observation period in the last quarter of 2014. It is important to recognize that both variables do not show any sign of recovery throughout the entire period. At the end of 2014, average output in Europe lost almost 24% and consumption lost almost 25% of its pre-crisis level. For both cases neither the level nor the growth rate has recovered to its pre-crisis trend, hence, a recovery from the initial shock and end of the Great Recession is still wishful thinking.

Investment on the other hand shows an even more radical picture. It drops in the first six periods of the crisis by almost 35%, more than three times the size of the drop in output during the same period. It temporarily settles down after that just to drop by another 20% in mid-2011. At the beginning of 2013 it settles down again and remains at this level of more than 40% below trend. 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.

labor input, as measured by total hours worked per capita, increases 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 6% until the end of the observation period.

3 Benchmark Prototype Model

The benchmark prototype model follows Chari, Kehoe and McGrattan (2007) with 1) a representative household, that maximizes its lifetime utility gained from consumption and leisure, 2) a representative firm that maximizes profits by periodically choosing how much labor to hire and capital to rent, and 3) the government sector that collects distortionary taxes in order to finance its exogenous expenditure.

3.1 Household's problem

The representative consumer maximizes expected lifetime utility:

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

where E is the expectations operator for all future values in time t, and $\beta \in$ (0,1) is the discount factor for future utility.

The period utility depends on consumption c_t, and leisure $1-h_t$:

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

where ψ is a preference weight parameter.

The household's budget constraint is

$$(1-\tau_{h,t})w_t h_t + r_t k_t + \pi_t + \tau_t = c_t + (1+\tau_{i,t})i_t, \tag{2}$$

where w_t is the wage rate, r_t is the real rental rate, k_t is the capital stock, π_t is the firm's profits paid back to the household as the dividends to the owner of the firm, τ_t is the lump-sum transfer paid by the government, and i_t is gross capital investment. $\tau_{h,t}$ and $\tau_{i,t}$ are the tax rates on labor income and investment, respectively.

The capital stock follows the law-of-motion:

$$\Lambda k_{t+1} = i_t + (1-\delta)k_t \tag{3}$$

where δ is the depreciation rate and Λ is the growth trend of the economy which consists of population growth and productivity growth.

3.2 Firm's Problem

The firm maximizes profits:

$$\pi_t = y_t - w_t h_t - r_t k_t \tag{4}$$

by choosing labor input h_t and capital k_t, and thereby determining output y_t. The production function is assumed to be Cobb-Douglas:

$$y_t = z_t k_t^{\theta} h_t^{1-\theta} \tag{5}$$

where z_t is the time-varying production efficiency and θ is the capital intensity.

3.3 Government

The government sector collects taxes in order to finance its expenditure and rebates the remainder to the consumer in form of lump-sum transfers. Hence, the government's budget constraint is:

$$\tau_{h,t} w_t h_t + \tau_{i,t} i_t = \tau_t + g_t \tag{6}$$

where g_t stands for government consumption.

If we substitute the government budget constraint (6) and the firm's problem (4) into the household budget constraint (2) we obtain the resource constraint:

$$y_t = c_t + i_t + g_t. \tag{7}$$

3.4 Wedges

For convenience, we define efficiency, government, investment and labor wedges as follows. The efficiency wedge is equivalent to the Solow residuals or total factor productivity, and is defined as:

$$\omega_{e,t} = \frac{y_t}{k_t^\theta h_t^{1-\theta}} = z_t.$$

The government wedge is defined as the difference between the goods produced in an economy, and the goods available to its private agents:

$$\omega_{g,t} = y_t - c_t - i_t = g_t,$$

which is equivalent to government purchases.

The investment wedge is defined as a friction in the capital Euler equation

$$\omega_{i,t} = \frac{\Lambda}{\beta} E\left[\frac{\frac{c_{t+1}}{c_t}}{\theta\frac{y_{t+1}}{k_{t+1}} + \frac{1-\delta}{\omega_{it+1}}}\right] = \frac{1}{1+\tau_{i,t}}, \tag{8}$$

which drives a wedge between the inter-temporal marginal rate of substitution of current consumption to future consumption and the marginal return to investment.

The labor wedge is defined as a friction in the labor market equilibrium condition

$$\omega_{h,t} = \frac{\frac{1-\psi}{\psi}\frac{c_t}{1-h_t}}{(1-\theta)\frac{y_t}{h_t}} = 1 - \tau_{h,t},$$

which drives a wedge between the intra-temporal marginal rate of substitution of leisure to consumption and the marginal product of labor.

3.5 Equilibrium

A competitive equilibrium in this model is a sequence of prices $\{w_t, r_t\}_{t=0}^{\infty}$ and quantities $\{y_t, c_t, i_t, h_t, k_{t+1}\}_{t=0}^{\infty}$ and wedges $\{\omega_{e,t}, \omega_{g,t}, \omega_{i,t}, \omega_{h,t}\}_{t=0}^{\infty}$ such that:

1. The household maximizes utility taking$\{w_t, r_t, \omega_{g,t}, \omega_{i,t}, \omega_{h,t}\}_{t=0}^{\infty}$ and an initial value of k_0 as given;

2. The firm maximizes profits taking $\{w_t, r_t, \omega_{e,t}\}_{t=0}^{\infty}$ as given;

3. Labor and capital markets clear for every period;

4. The government budget constraint (6) and resource constraint (7) hold for every period; and

5. The exogenous variables follow a stochastic process.

$$\begin{aligned} \widetilde{\omega_{t+1}} &= P\widetilde{\omega}_t + \varepsilon_{t+1} \\ \varepsilon &\sim N(0, V) \end{aligned} \tag{9}$$

   where $\omega_t = (\omega_{e,t}, \omega_{g,t}, \omega_{i,t}, \omega_{h,t})'$, P is a 4×4 transition matrix, and $\varepsilon_t = (\varepsilon_{e,t}, \varepsilon_{g,t}, \varepsilon_{i,t}, \varepsilon_{h,t})'$ are innovations that have a standard normal distribution with zero-mean and a variance-covariance matrix V.[4]

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

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

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

$$y_t = c_t + i_t + \omega_{g,t},$$

$$y_t = \omega_{e,t} k_t^{\theta} h_t^{1-\theta},$$

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

3.6 Equivalence Results and The Financial Crisis

A useful interpretation of the business cycle accounting model is that it nests several classes of detailed models. In context of the recent financial crisis, Buera and Moll (2015) shows that we can map several credit crunch recession

[4] The variance-covariance matrix is unrestricted in the sense that it allows for simultaneous correlations of innovations.

models into prototype models with efficiency, investment and labor wedges. The common feature of these models are that each firm i faces a constraint on external finance which states that the borrowing d cannot exceed a fraction of capital k:

$$d_{i,t+1} \leq \theta_t k_{i,t+1}.$$

A tightening of the borrowing constraint in the form of a drop in θ represents a credit crunch. Business cycle accounting is therefore useful in detecting the channel through which the credit crunch could have operated.

3.6.1 Efficiency Wedge, $\omega_{e,t}$

The efficiency wedge is equivalent to the Solow residual which is often referred to as "productivity". This can include technological progress driven by inventions and innovations, factor utilization, accumulation of human capital and general production efficiency. This can also include allocative efficiency of the aggregate economy. Chari, Kehoe and McGrattan (2007) shows that a model with input financing frictions, in which heterogeneous credit spreads faced by intermediate goods producers lead to suboptimal resource allocation, can be mapped into a prototype model with efficiency wedges. Buera and Moll (2015) shows that a model with heterogeneous firm productivity and external borrowing constraints can be mapped into a prototype model with efficiency wedges.[5] In their model, a tightening of the borrowing constraint reduces the amount the most productive firms can borrow and increases resources allocated towards less productive firms which would otherwise have been lent to the productive firms.

3.6.2 Investment Wedge, $\omega_{i,t}$

The investment wedge is defined as distortionary tax on investment expenditures. However, various market distortions and shocks can be observationally equivalent to investment wedges in a business cycle accounting context. Chari, Kehoe and McGrattan (2007) shows that a model with financial frictions arising from costly state verification as in Bernanke, Gertler and Gilchrist (1999) can be mapped into a prototype model with investment

[5] In their detailed model, investment and labor wedges also exist between the household and entrepreneurs.

wedges.[6] Inaba and Nutahara (2009) shows that a financial friction model a la Carlstrom and Fuerst (1997) can be mapped into a prototype model with investment wedges. Klein and Otsu (2013) shows that a model with expectational shocks to future output can be mapped into a prototype model with investment wedges. Brinca, Chari, Kehoe and McGrattan (2016) shows that a model with financial frictions arising from a bank collateral constraint as in Gertler and Kiyotaki (2010) can be mapped into a prototype model with investment wedges. In their model, they assume an exogenous decline in the quality of capital as the direct financial shock. Buera and Moll (2015) shows that a model with heterogeneous investment costs among firms can be mapped into a prototype model with investment wedges. In their model, a tightening of the borrowing constraint will prevent resources to flow into the firm with lowest investment cost and hence increase the marginal cost of investment.

3.6.3 Labor Wedge, $\omega_{h,t}$

The labor wedge is defined as distortionary tax on labor income. However, various market distortions can manifest themselves as labor wedges. Chari, Kehoe and McGrattan (2007) shows that a model with nominal wage rigidity and monetary shocks can be mapped into a prototype model with labor wedges. Klein and Otsu (2013) shows that a model with time varying labor union bargaining power as in Cole and Ohanian (2004) can be mapped into a prototype model with labor wedges. Otsu (2010a) shows that a model with a working capital constraint on labor such as Jermann and Quadrini (2012) in which an increase in labor cost due to rising credit spreads can be mapped into a prototype model with labor wedges. Buera and Moll (2015) shows that a model with labor search frictions and heterogeneous recruitment costs among firms can be mapped into a prototype model with labor wedges. In their model, a tightening of the borrowing constraint will prevent resources to flow into the firm with lowest recruitment cost and hence increase the marginal cost of labor.

[6] Chari, Kehoe and McGrattan (2007) show that a model based on Bernake, Gertler and Gilchrist (1999) maps into a prototype model with taxes on capital income rather than taxes on investment expenditure.

3.6.4 Government Wedge, $\omega_{g,t}$

Although the government wedge is not directly linked to the credit crunch per se, it is worth mentioning how government expenditure evolved in Europe during the post-crisis slump period. In November 2008 the European Commission proposed a 200 billion Euros European Economic Recovery Plan and recommended EU member states to implement national expenditure plans approximately equal to 1.2 percent of GDP. This should increase government wedges and increase output through an increase in aggregate demand. However, several European countries countered these plans later on and introduced fiscal austerity measures in fear of the increasing government debt. Fiscal consolidation should have the opposite effect on GDP from that of the fiscal stimulus plan.

4 Quantitative Analysis

The Business Cycle Accounting procedure follows Chari, Kehoe and McGrattan (2007). In the first step parameter values are obtained through calibration and structural estimation using macroeconomic data. In the second step the model is solved numerically through linear solution methods. In the third step, wedges are backed out using the linearized decision rules and linearly detrended data. In the last step we plug in one wedge at a time and simulate the model in order to decompose the business cycle fluctuations into the contributions of each wedge.

4.1 Calibration

Table 2 shows the list of parameters we calibrate in order for the model to match data over the 1995Q1-2007Q4 period. All parameters are country-specific and are calibrated to data of each country. We report the average value and the highest and lowest among the 29 countries. The list of country-specific parameter values are available upon request.

Table 2. Calibrated Parameters

Parameter	**Description**	Average	Max	Min
δ	Depreciation rate	0.008	0.015	0.002
θ	Capital share	0.392	0.545	0.190
Λ	Growth trend	0.009	0.018	0.003
$\widehat{\beta}$	Subjective discount factor	0.984	0.996	0.966
ψ	Preference weight	0.178	0.242	0.121

The depreciation rate δ is calibrated to match the capital law-of-motion:

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

to the average capital stock and investment data of Penn World Tables 8.0. Since the data is in annual frequency, we divide the average annual depreciation rate by 4 in order to obtain the average quarterly rate of depreciation.

The capital share θ is calibrated to match the labor share data computed by the method of Gollin (2002). First, the naïve labor income share is computed as

$$1 - \theta^n = \frac{\textit{Compensation of Employees}}{\textit{GDI - Taxes on Production and Imports less Subsidies}}.$$

Then, the labor share of income is adjusting for self-employed workers:

$$1 - \theta = (1 - \theta^n)\frac{\textit{Total Employment}}{\textit{Number of Employees}}.$$

The data for compensation of employees, taxes on production and imports less subsidies, and employees are obtained from Eurostat.

The growth trend Λ is computed as the average quarterly growth rate of total GDP. This consists of the average growth of population and the labor augmenting technical progress.

The subjective discount factor $\widehat{\beta}$ is calibrated to match the steady-state capital-output ratio in the capital Euler equation to that in data as

$$\widehat{\beta} = \frac{1}{\theta\frac{y}{k} + 1 - \delta}.$$

Notice that for convenience we have define the discount factor as

$$\widehat{\beta} = \frac{\beta}{\Lambda}.$$

The preference weight parameter ψ is calibrated to match the steady state labor input level in the labor first order condition to that in data as

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

We assume that the available working hours is 14 hours per day and normalize total hours worked per quarter h as

$$h = \frac{\text{total hours worked}}{\text{adult population} \times 14 \times \frac{365}{4}}.$$

4.2 Estimation

In the case of efficiency, labor, and government wedges, the values can be computed directly using data. In the case of the investment wedge, however, it is not so simple because as seen in equation (8) current investment wedges depend on expected future values of the economy's variables in the future. It follows that in order to compute the investment wedge in time t, we need to understand the stochastic process governing economic variables to make inferences about how the economy is going to behave in subsequent periods. Therefore we estimate the stochastic process of the wedges with Bayesian maximum likelihood estimation treating the investment wedges as a latent variable.[7]

We set the estimation period from 1995Q1 to 2007Q4 which we define as the pre-crisis period. The last period before the crisis is estimated through the Bai-Perron multiple unknown breakpoint test. The estimated breakpoint was not the same for every country so we used the most common breakpoint

[7] Our priors are a generic transition matrix and variance covariance matrix:

$$P = \begin{pmatrix} 0.9 & 0 & 0 & 0 \\ 0 & 0.9 & 0 & 0 \\ 0 & 0 & 0.9 & 0 \\ 0 & 0 & 0 & 0.9 \end{pmatrix}, V = \begin{pmatrix} 0.01 & 0 & 0 & 0 \\ 0 & 0.01 & 0 & 0 \\ 0 & 0 & 0.01 & 0 \\ 0 & 0 & 0 & 0.01 \end{pmatrix}.$$

2007Q4 in order to assume conformity. Due to data availability issues, the estimation period of the countries listed in Table 3 starts on a later date than 1995Q1.[8]

Table 3. Truncated Simulation Process

Country	**Start Date**	**Country**	**Start Date**
Belgium	1999Q1	Latvia	2000Q1
Czech Republic	1996Q1	Luxembourg	2003Q1
Estonia	2000Q1	Malta	2000Q1
Hungary	2001Q1	Poland	2000Q1
Iceland	2003Q1	Slovakia	1997Q1
Ireland	1998Q1		

4.3 Accounting Results

Given the parameter levels obtained through calibration and estimation, we define the linearized state space representation of the model as follows:

$$\widetilde{k_{t+1}} = A\widetilde{k_t} + B\widetilde{\omega_t}, \tag{10}$$

$$\widetilde{v_t} = C\widetilde{k_t} + D\widetilde{\omega_t}, \tag{11}$$

where $v_t = (y_t, c_t, i_t, h_t)'$. The decision rule matrices A, B, C, D are solved through a standard linear solution method implemented by Uhlig (1999).

We assume that the economy is at steady state in 2007Q4 so that $\widetilde{k_{2007Q4}} = 0$. Then, we can compute the full series of capital stock from the capital law of motion

$$\Lambda\widetilde{k_{t+1}} = \frac{i}{k}\widetilde{i_t} + (1-\delta)\widetilde{k_t}.$$

starting from $t = 2007Q4$ given that $\widetilde{i_t}$ is observable.

From the measurement equation (11) we can compute the wedges for all periods as

$$\widetilde{\omega_t} = D^{-1}\left(\widetilde{v_t} - C\widetilde{k_t}\right),$$

given that $\widetilde{v_t}$ is observable.

[8]In order to check whether the simulation results in these countries are affected by the reduced simulation period, we simulate the model with the generic transition and variance covariance matrixes. We find that the simulation results are robust so that the estimated parameters of the stochastic process are not the main drivers of the simulation results.

The simulation is conducted by plugging in each wedge one by one into the model:

$$\begin{aligned} \widetilde{k_{j,t+1}} &= A\widetilde{k_{j,t}} + B\widetilde{\omega_{j,t}}, \\ \widetilde{v_{j,t}} &= C\widetilde{k_{j,t}} + D\widetilde{\omega_{j,t}}. \end{aligned}$$

By construction, as shown in Otsu (2012) the sum of all simulated series will perfectly replicate the data fluctuations:

$$\sum_j \widetilde{v_{j,t}} = \widetilde{v}_t.$$

In the following section, we decompose the post-crisis slump of output into the contributions of each wedge:

$$cont(\omega_j) = \frac{v_{\widetilde{j,2014Q4}}}{v_{\widetilde{2014Q4}}}.$$

The contributions will sum up to one.

4.3.1 Computed Wedges

Figure 3 shows the time paths of each wedge over the 2007Q4-2014Q4 period. The solid line with circular markers is the observed cross-country mean value of output. The solid line with crossed markers is the cross-country mean value of the computed wedge. The dashed lines represent the 95% bootstrap confidence interval for the computed wedges.

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 labor wedge initially jumps up slightly at the onset of the crisis, but after that it starts to fall until the beginning of 2013, where it levels off at around negative 9%. Throughout the entire data period the investment wedge does not seem to deteriorate on average. Government wedges rise during the 2008-2009 period, reflecting the fiscal stimulus policy known as the European Economy Recovery Plan, followed by a gradual decline reflecting the fiscal austerity measures. The confidence interval, however, is very wide compared to other wedges especially during the initial periods.

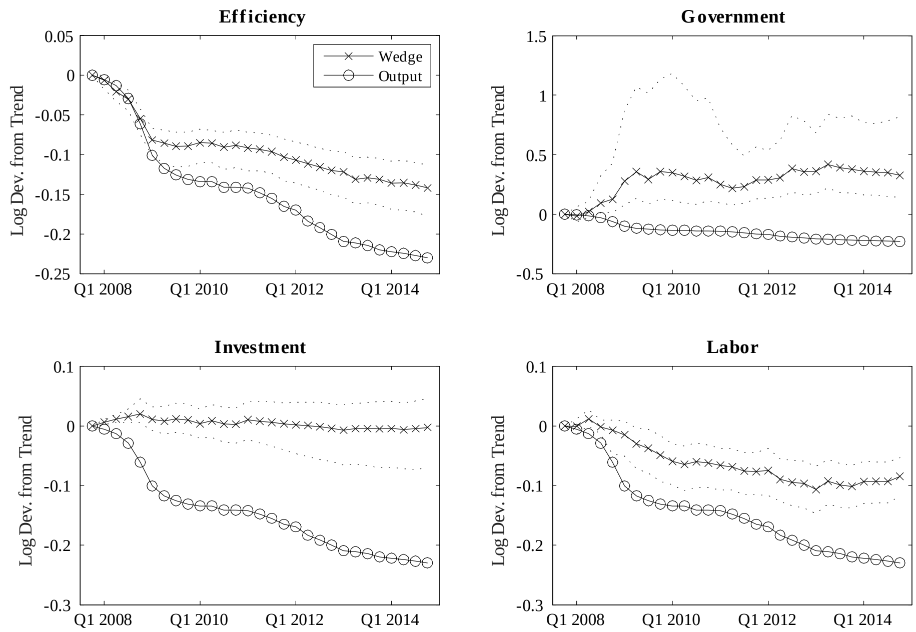

Figure 3: Computed Wedges

4.3.2 Average Simulation Results

Figure 4 shows the model's output response to each wedge.[9] The simulation with only efficiency wedges closely follows observed output performance in the post-crisis period. In the first year of the crisis the simulated output drop is almost identical to data. After that the gap between the simulated output and data slightly widens although the observed data is still contained by the 95% confidence interval. In 2014Q4 observed cross-country mean output is 23.5% below the 2007Q4 level, while the predicted cross-country mean output is 21.2% below it. Therefore, feeding in the efficiency wedge into the prototype model accounts for more than 90% of the observed post-crisis output drop in Europe. 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 1.7% in 2014Q4. Consequently,

[9]By construction feeding all 4 wedges back into the model gives us simply the observed data.

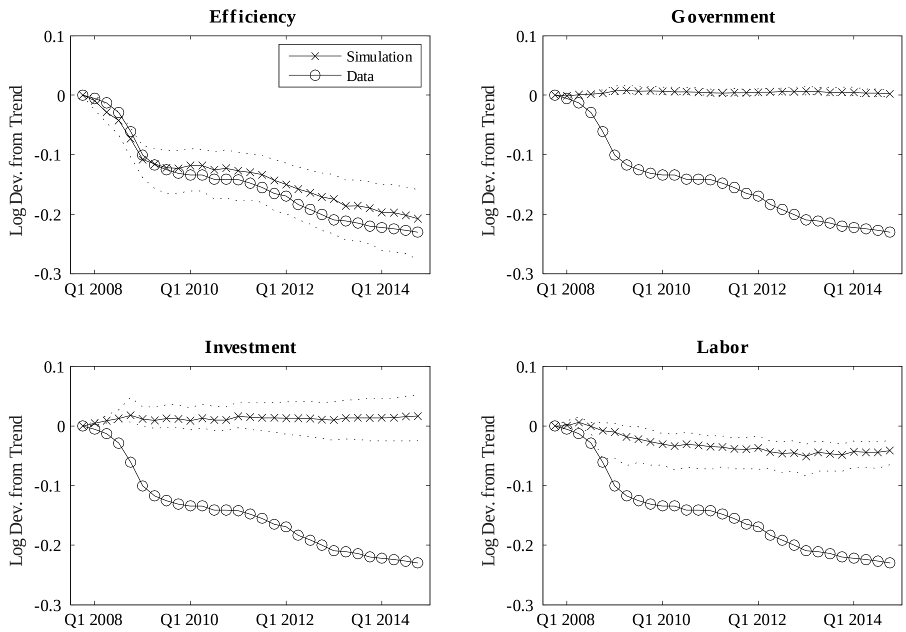

Figure 4: Accounting Result: Output

the labor wedges account for the remaining output to fall by about 4.3%.

Figure 5 shows the drop in simulated consumption vs. the observed consumption. The most important wedge in accounting for the drop consumption is the efficiency wedge. The model simulated with only efficiency wedges predicts consumption in 2014Q4 to be 17.9% below the 2007Q4 period compared to an observed fall in output of 24.5%. Again, the labor wedge closes the gap by predicting a drop in consumption of about 5.7%. The models simulated with the government and the investment wedge do not predict the drop in consumption in any meaningful way.

Figure 6 shows the simulation results for investment, which emphasizes the dominance of the efficiency wedge even more. We can clearly see that the model with only efficiency wedges closely replicates the observed performance of investment in the post-crisis period until 2014Q4. Both the government and labor wedges led to slight drops over the post-crisis period by 3% and 4% respectively. However, the most interesting result is that the model with only investment wedges can only account for 5.5% of the observed investment

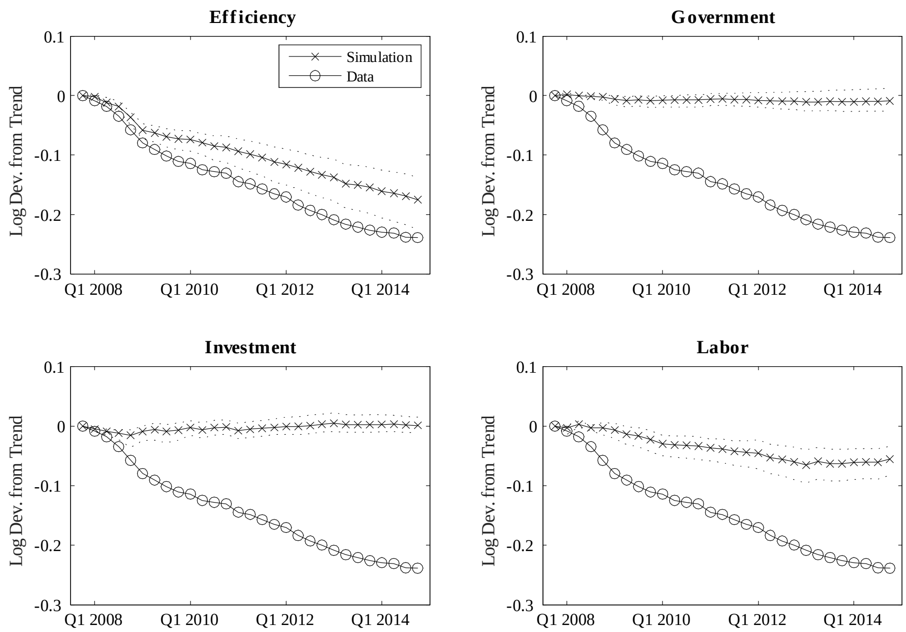

Figure 5: Accounting Result: Consumption

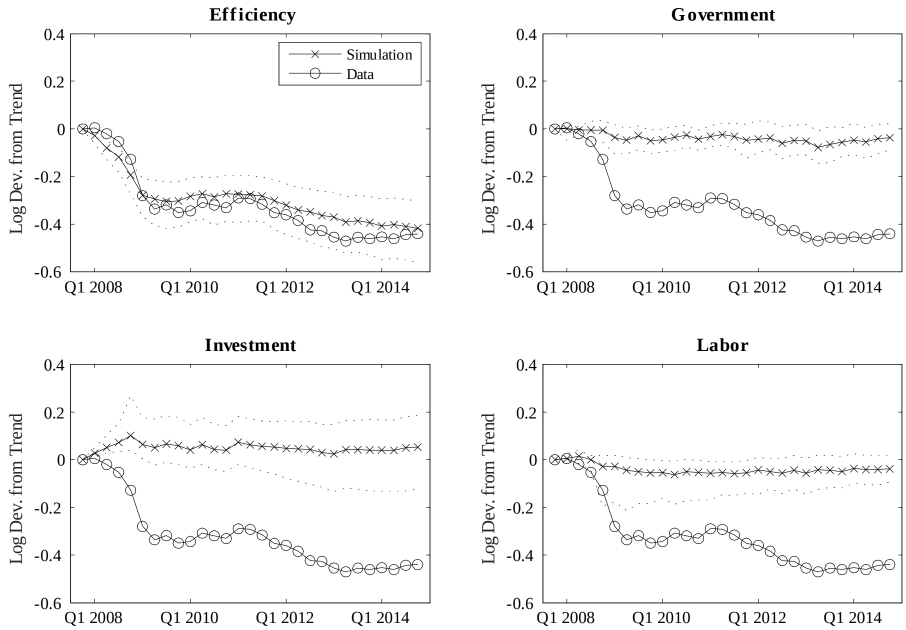

Figure 6: Accounting Result: Investment

drop.

Figure 7 shows the simulation results for labor, which gives a different picture from the previous simulations. The model with only labor wedges almost exactly replicates the observed data in labor input. The model with only efficiency wedges predicts only a drop of 2.7% in labor where the drop is actually 6.0% in the data. The model with government and investment wedges predicts slight increase in labor.

4.3.3 Country Specific Simulation Results

Table 4 presents the simulation results of output for each individual country.[10] 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

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

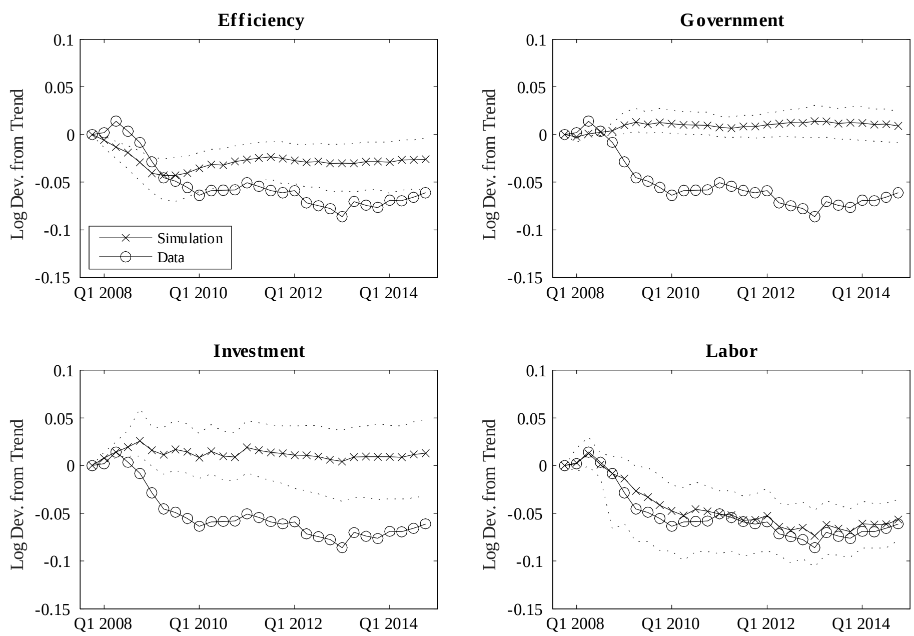

Figure 7: Accounting Result: Labor

tender by the end of 2014. The following 8 countries, Czech Republic up to the United Kingdom, belong to the European Union, but did not adopt the Euro currency as their official medium of exchange. Norway and Switzerland, the 2 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 first column shows the total output drop over the 2007Q4-2014Q4 period. The only country that seems to have recovered from the crisis is Malta with a post-crisis average output growth of 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, and Lithuania. Countries with an output loss roughly 30% or more sum up to 10 (including Luxembourg). Countries with an output loss roughly 20% or more amount to 19 (including Italy, Portugal, and Norway). The following columns report the contribution of each wedge on output drop measured as the simulated output drop relative to the output drop in the data. The main picture we get from this analysis is that indeed the efficiency wedge is the most important wedge explaining the drop in observed post-crisis output. The observed output drop in Estonia, Finland, Italy, Lithuania, Netherlands, Poland, Sweden, and Norway can almost exclusively be explained by the efficiency wedge. However, some countries do not match that pattern. For Cyprus, Greece, Malta, Spain, and Romania the wedge that drives output is, surprisingly, the investment wedge. In these cases, the efficiency wedge comes second or even third.

We further assess the differences in the magnitude of output drop across countries in Table 5. First, we regress output drop on the decline in efficiency wedges in each country:

$$\Delta y_n = \alpha + \sum_j \beta_j \times \Delta \omega_{j,n} + \varepsilon_n,$$

where $j = e, i, h$ and Δy_j and $\Delta \omega_{kj}$ are the drops in output and wedges between 2007Q4 and 2014Q4 in each country n respectively. Since Malta is a clear outlier we focus on the remaining 28 countries for the regression. The results show that the greater the decline in wedges the greater the output drop. In specific, a 1% decline in efficiency, investment and labor wedges lead to declines in output by 1.24%, 0.09% and 0.55% respectively.

Table 4. Country-Specific Post-Crisis Behavior

Country	Output Drop (%) 2007Q4-2014Q4	Wedge Contributions (%) ω_e	ω_g	ω_i	ω_h
Austria	14.89	65.3	0.1	27.6	7.1
Belgium	13.47	137.1	9.2	−27.7	−18.5
Cyprus	36.00	31.3	4.7	67.1	−3.1
Estonia	50.69	99.2	1.8	−20.0	19.1
Finland	34.28	117.7	2.6	−18.8	−1.4
France	12.07	86.6	0.9	−12.6	25.1
Greece	48.87	45.1	2.0	48.9	3.9
Germany	5.62	153.4	−2.1	−45.4	−5.9
Ireland	30.95	38.6	3.1	24.7	33.6
Italy	19.52	95.8	−4.6	−40.7	49.5
Latvia	53.38	131.2	−1.6	−44.9	15.4
Lithuania	37.24	107.8	−2.4	−39.9	34.6
Luxembourg	26.03	145.5	−5.1	−33.6	−6.8
Malta	*-0.49*	*189.4*	*-66.2*	*194.8*	*-218.0*
Netherlands	21.07	89.9	1.2	−22.9	31.9
Portugal	19.53	45.0	−10.3	13.6	51.8
Slovakia	20.81	119.2	−4.4	−46.6	31.8
Slovenia	30.82	139.3	−3.5	−50.0	14.3
Spain	23.32	23.1	−9.3	50.7	35.6
Czech Republic	20.19	135.6	0.2	−52.0	16.2
Denmark	21.64	53.3	7.1	28.3	11.4
Hungary	21.72	47.3	3.3	41.2	8.2
Poland	5.81	91.0	−0.3	−8.2	17.5
Romania	7.55	30.6	−63.9	97.5	35.8
Sweden	18.34	112.4	6.4	−17.1	−1.6
United Kingdom	16.62	127.6	3.3	−56.1	25.2
Iceland	29.25	79.5	−13.9	−38.0	72.4
Norway	19.12	114.5	9.3	−1.1	−22.8
Switzerland	8.90	88.2	−0.9	4.5	8.3

Next, we regress the output drop on the contributions of each wedge:

$$\Delta y_n = \alpha + \sum_j \beta_j \times cont(\omega_j)_n + \varepsilon_n,$$

where $cont(\bullet)$ represents the contribution of each wedge j on the output drop in each country. The results show that there is no clear pattern regarding the contribution of each wedge and the output drop where the adjusted R^2 is extremely low.

Table 5. Magnitude of Output Drop

Dependant Variable: Δy			
$\Delta\omega_{e,j}$	1.291^{**}	$cont(\omega_A)$	-0.319^{**}
	(0.078)		(0.133)
$\Delta\omega_{i,j}$	0.090^{*}	$cont(\omega_i)$	-0.291^{**}
	(0.049)		(0.082)
$\Delta\omega_{h,j}$	0.556^{**}	$cont(\omega_h)$	-0.205^{*}
	(0.084)		(0.112)
Constant	0.000	Constant	0.547^{**}
	(0.026)		(0.137)
R^2	0.936	R^2	-0.044
N	28	N	28

4.3.4 Regional Differences

Following Cho and Doblas-Madrid (2013), we look into the regional differences in the experiences by dividing countries into the following groups: Eastern Europe and Western Europe, Southern Europe and Northern Europe, Euro area and Non-Euro area, Nordic countries and the rest of Europe, BeNeLux countries and the rest of Europe, British Isles and the rest of Europe. Countries defined as Eastern Europe are Estonia, Latvia, Lithuania, Slovakia, Slovenia, Czech Republic, Hungary, Poland, and Romania. Countries defined as Southern Europe are Cyprus, Greece, Italy, Portugal, and Spain. Countries in the Euro are Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Luxembourg, Netherlands, Portugal, Slovakia, Slovenia, and Spain. Nordic countries are Denmark, Finland, Iceland, Norway, and Sweden. BeNeLux countries are Belgium, Luxembourg, and the Netherlands. British Isles are Ireland and the United Kingdom.

We first consider the effects of regional differences on the magnitude of the deterioration in wedges. The first 3 columns of Table 6 presents the estimation result of the following regression:

$$\Delta\omega_{j,n} = \alpha + \beta_d \times D_{r,n} + \varepsilon_n,$$

where $j = e, i, h$ and $D_{r,n}$ stands for the regional dummy. The first column shows that Eastern Europe, Euro Area, Nordic Countries and BeNeLux countries experienced a greater drop in efficiency wedges. The second column shows that Southern Europe experienced greater drops while BeNeLux countries experienced smaller drops in investment wedges. The third column shows that Eastern Europe, Southern Europe and British Isles experienced greater drops in labor wedges.

We next consider the effects of regional differences on the decline in each wedge. The last 3 columns of Table 6 summarizes the estimation results of the following regression:

$$cont(\omega_j)_n = \alpha + \beta_d \times D_{r,n} + \varepsilon_n.$$

The fourth column shows that the contribution of efficiency wedges are lower in Southern Europe than other regions. The fifth and sixth columns show that regional differences cannot explain the cross-country differences in the contributions of investment and labor wedges given the low adjusted R^2. This result confirms that Southern Europe is an exception in which investment wedges (Cyprus, Greece and Spain) and labor wedges (Portugal) play significant roles.

Table 6. Effects of Regional Differences on Wedges and Their Contributions

Regional Dummy	Dependent Variable					
	$\Delta\omega_A$	$\Delta\omega_i$	$\Delta\omega_h$	$cont(\omega_A)$	$cont(\omega_i)$	$cont(\omega_h)$
Eastern Europe	0.135**	−0.070	0.070**	0.072	−0.134	0.118
	(0.043)	(0.043)	(0.020)	(0.207)	(0.196)	(0.070)
Southern Europe	0.033	0.237**	0.154**	−0.548**	0.395	0.197
	(0.042)	(0.099)	(0.024)	(0.241)	(0.259)	(0.137)
Euro Area	0.084*	−0.038	0.016	0.178	−0.203	−0.032
	(0.041)	(0.039)	(0.026)	(0.168)	(0.195)	(0.061)
Nordic Countries	0.139**	−0.047	0.025	0.069	−0.141	0.012
	(0.034)	(0.030)	(0.038)	(0.214)	(0.195)	(0.159)
BeNeLux	0.076**	−0.113**	−0.034	0.213	−0.165	−0.057
	(0.046)	(0.046)	(0.030)	(0.261)	(0.168)	(0.159)
British Isles	0.051	0.031	0.127*	−0.108	−0.143	0.200**
	(0.069)	(0.112)	(0.071)	(0.472)	(0.439)	(0.078)
Constant	0.01	0.025	0.016	0.850**	0.088	0.110
	(0.04)	(0.038)	(0.023)	(0.197)	(0.190)	(0.070)
R^2	0.181	0.336	0.313	0.175	−0.007	−0.067
N	28	28	28	28	28	28

5 Discussion: Financial Variables and the Efficiency Wedge

Given the nature of the financial crisis, we investigate the association between the cross-country differences in the decline in wedges and changes in financial variables. The financial variables we consider are the private domestic credit to GDP ratio (DC), non-performing loans to total loans ratio (NPL), the market capitalization to GDP ratio (MC), and the housing price index (HPI).[11] The data are from the World Bank World Development Indicators.

Table 7 reports the summary statistics of the financial variables. We consider both the level of these financial variables in 2007 (denoted as 07) and the change in these variables over the 2007 to 2014 period (denoted as gr).[12] This table shows that domestic credit and market capitalization fell

[11] Market capitalization is defined as the total value of shares in the economy.

[12] Since the Housing price index cannot be compared across countries, only consider the change in housing price index. Due to data availability, the change in market capitalization is measured over the 2013 and 2014 period.

by 1.4% and 15.6% relative to GDP respectively while non-performing loans increased by 18.7% relative to total loans after the crisis. The housing price index declined only slightly during this period on average. The decline in domestic credit being greater than that in GDP represents the credit crunch while the decline in market capitalization and rise in non-performing loans illustrates a broader concept of financial crisis.

Table 7. Financial Variables Summary Statistics

Variable	N	Mean	Median	Std. Dev.
$DC07$	27	4.538	4.484	0.571
$DCgr$	27	-0.014	-0.009	0.045
$NPL07$	25	0.177	0.151	1.042
$NPLgr$	27	0.187	0.156	0.130
$MC07$	28	4.199	4.260	0.866
$MCgr$	28	-0.156	-0.132	0.123
$HPIgr$	25	-0.006	-0.009	0.009

In order to investigate the relationship between the financial market and production efficiency, we run the following regression:

$$\Delta\omega_{j,n} = \alpha + \sum_f \beta_f \times F_{f,n} + \varepsilon_n,$$

where $F_{f,n}$ stands for the financial variables listed above. Data availability limits the sample to 22 countries. Table 8 summarizes the regression results.

The first column presents the results for efficiency wedges. This shows that both the level and growth of non-performing loan, the growth of market capitalization and the growth of house price index have negative effects on the drop of efficiency wedges. The results that countries with larger declines in domestic credit to GDP ratio do not necessarily have a larger decline in efficiency wedges is interesting.[13] This implies that the severity of the credit crunch cannot explain the magnitude of the decline in the efficiency wedge. Instead, the declines in stock market and real estate market indicators are highly associated with the efficiency wedge decline. However, we cannot infer causality from these variables. One result that is particularly interesting is that the countries with higher growth in nonperforming loans experience less

[13] This does not change when we change the variable to the growth rate of domestic credit instead of the GDP ratio.

decline in efficiency wedges. This is in fact consistent with the zombie lending phenomenon documented by Caballero, Hoshi and Kashyap (2008) which states that financial institutions roll over loans to insolvent low productivity firms and collect from solvent high productivity firms in order to avoid non-performing loans and maintain a superficially healthy balance sheet.[14] Therefore, a promising avenue for future research is to investigate the zombie phenomenon in Europe.

The second column presents the results for investment wedges. This shows that the growth in domestic credit and the level and growth of non-performing loans are positively associated with a deterioration in investment wedges. It is straight forward to show why an increase in non-performing loans can lead to higher investment wedges if we consider the increase in default risk leading to an increase in borrowing costs. It is not clear, however, why countries with a more severe credit crunch experiences less deterioration in investment wedges.

The third column presents the results for labor wedges. This shows that the growth in the housing price index has a negative effect on labor wedges. This is consistent with models with working capital constraint on labor where land serves as collateral in which a credit crunch leads to a deterioration in labor wedges by increasing the labor cost. However, the result that the severity of the credit crunch is not statistically related to the severity of the deterioration in labor wedges implies that this mechanism is not the only one operating in the labor market.

[14] The result that the level of non-performing loans has a negative effect of the decline in efficiency wedges can also be related to zombie lending. A high proportion of non-performing loans in a country can indicate the tendency of the economy to avoid zombie lending. Alternatively, this can imply that insolvent firms already exited the market in 2007 and a smaller proportion of insolvent firms are left to turn into zombies.

Table 8. Effects of Financial Variables on Wedges

	$\Delta\omega_A$	$\Delta\omega_i$	$\Delta\omega_h$
$DC07$	-0.021	0.132	0.059
	(0.034)	(0.104)	(0.038)
$DCgr$	-0.390	1.852^{*}	0.225
	(0.331)	(1.015)	(0.376)
$NPL07$	-0.061^{**}	0.081^{**}	0.018
	(0.010)	(0.030)	(0.011)
$NPLgr$	-0.334^{**}	0.997^{**}	0.229
	(0.121)	(0.371)	(0.137)
$MC07$	-0.018	0.058	-0.015
	(0.016)	(0.050)	(0.018)
$MCgr$	-0.714^{**}	-0.348	-0.035
	(0.154)	(0.471)	(0.174)
$HPIgr$	-4.484^{*}	-1.802	-4.746^{**}
	(1.929)	(5.917)	(2.189)
$Constant$	0.270^{**}	-1.072^{**}	-0.194
	(0.125)	(0.384)	(0.142)
R^2	0.815	0.506	0.732
N	22	22	22

6 Conclusion

In this paper we reviewed the economic experience of 29 European economies from the onset of the Great Recession in early 2008 until the end of 2014. We found that efficiency wedges are most important in accounting for the post-crisis slump in most of the countries except for Southern Europe in which investment wedges (Cyprus, Greece and Spain) and labor wedges (Portugal) have higher contribution. Therefore, in most part of Europe the mechanism through which the financial crisis operated during this period is a deterioration in production efficiency. This is consistent with recent literature of financial crises in which credit crunches lead to deterioration in aggregate production efficiency through misallocation across firms with heterogeneous productivity.

We further investigate the source of cross-country differences in the magnitude of efficiency wedge declines and find that countries in which non-performing loans decline more experience less decline in efficiency wedges.

This implies that misallocation in the form of zombie lending is a promising explanation to the cross-country difference in efficiency loss during the European post-crisis slump. We also find that countries with higher growth in non-performing loans experienced a greater deterioration in investment wedges. Finally, countries with a greater decline in the housing price index experienced a greater deterioration in labor wedges. Further studies should focus on how non-performing loans and housing prices operate through each wedge during financial crises.

References

[1] Adjemian, S., H. Bastani, M. Juillard, F. Mihoubi, G. Perendia, M. Ratto, and S. Villemot, Dynare: Reference Manual Version 4, Dynare Working Paper Series, 1, 2011.

[2] Bernanke, B., M. Gertler and S. Gilchrist, The financial accelerator in a quantitative business cycle framework, *Handbook of Macroeconomics*, vol.1C, ch.21, 1999, pp.1341-1393.

[3] Brinca, P., Distortions in the neoclassical growth model: A crosscountry analysis. Journal of Economic Dynamics and Control, 47(C), 2014, pp.1-19.

[4] Brinca, P., V.V. Chari, P. Kehoe and E. McGrattan, Accounting for Business Cycles, *Handbook of Macroeconomics*, 2016, forthcoming.

[5] Buera, F. and B. Moll, Aggregate implications of a credit crunch: The importance of heterogeneity, *American Economic Journal: Macroeconomics*, 7 (3), 2015, pp.1-42.

[6] Caballero, R. T. Hoshi and A. Kashyap, Zombie Lending and Depressed Restructuring in Japan, *American Economic Review*, 98(5), 2008, pp.1943-1977.

[7] Carlstrom, C. and T. Fuerst, Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis, *American Economic Review*, 87(5), 1997, pp.893-910.

[8] Chakraborty, S., The Boom and the Bust of the Japanese Economy: A Quantitative Look at the Period 1980–2000, *Japan and the World Economy*, 21 (1), 2009, pp.116–131.

[9] Chakraborty, S. and K. Otsu, Business cycle accounting of the BRIC economies, *B.E. Journal of Macroeconomics*, 13 (1), 2013, pp.381-413.

[10] Chari, V.V., P. Kehoe, and E. McGrattan, Business Cycle Accounting, *Econometrica*, vol.75 (3), 2007, pp.781-836.

[11] Cho, D. and A. Doblas-Madrid, Business Cycle Accounting East and West: Asian Finance and the Investment Wedge, *Review of Economic Dynamics*, 16(4), 2013, pp.724-744.

[12] Gertler, M. and P. Karadi, A model of unconventional monetary policy, Journal of monetary Economics, 58, 2011, pp.17-34.

[13] Gertler, M. and N. Kiyotaki, Financial Intermediation and Credit Policy in Business Cycle Analysis, Handbook of Monetary Economics, vol.3, ch.11, 2010, pp.547-599.

[14] Gertler, M., N. Kiyotaki and A. Queralto, Financial crises, bank risk exposure and government financial policy, Journal of Monetary Economics, 59, 2012, pp.S17-S34.

[15] Gilchrist, S. V. Yankov and E. Zakrajsek, Credit market shocks and economic fluctuations, *Journal of Monetary Economics*, vol.56 (4), 2009, pp.471-493.

[16] Inaba, M. and K. Nutahara, The role of investment wedge in the Carlstrom-Fuerst economy and business cycle accounting, *Economics Letters*, 105, 2009, pp.200-203.

[17] Jermann, U. and V. Quadrini, Macroeconomic effects of financial shocks, 2009, *American Economic Review*, 102 (1), pp. 238-271.

[18] Khan, A. and J. Thomas, Credit Shocks and Aggregate Fluctuations in an Economy with Production Heterogeneity, *Journal of Political Economy*, 121 (6), 2013, pp.1055-1107.

[19] Kiyotaki, N. and J. Moore, Credit Cycles, *Journal of Political Economy,* 105(2), 1997, pp. 211-248.

[20] Klein, A. and K. Otsu, Efficiency, Distortions and Factor Utilization during the Interwar Period, University of Kent School of Economics Discussion Papers, 2013, KDPE-1317.

[21] Kobayashi, K. and M. Inaba, Business cycle accounting for the Japanese economy, *Japan and the World Economy*, 2006, 18 (4), pp.418-440.

[22] Lama, R., Accounting for output drops in Latin America, *Review of Economic Dynamics*, 14 (2), 2011, pp.295-316.

[23] Otsu, K., A neoclassical analysis of the Asian crisis: Business cycle accounting for a small open economy, *B.E. Journal of Macroeconomics*, Topics 10 (1), 2010a, Article 17.

[24] Otsu, K., International Business Cycle Accounting, University of Kent School of Economics Discussion Papers, 2010b, KDPE-1010.

[25] Otsu, K., How well can business cycle accounting account for business cycles? *Economics Bulletin*, 32 (2), 2012, pp.1774-1784.

Recent Kent Discussion Papers in Economics

16/05: 'The Revenue Implication of Trade Liberalisation in Sub-Saharan Africa: Some new evidence', Lanre Kassim

16/04: 'The rise of the service economy and the real return on capital', Miguel León-Ledesma and Alessio Moro

16/03: 'Is there a mission drift in microfinance? Some new empirical evidence from Uganda', Francis Awuku Darko

16/02: 'Early Marriage, Social Networks and the Transmission of Norms', Niaz Asadullah and Zaki Wahhaj

16/01: 'Intra-household Resource Allocation and Familial Ties', Harounan Kazianga and Zaki Wahhaj

15/21: 'Endogenous divorce and human capital production', Amanda Gosling and María D. C. García-Alonso

15/20: 'A Theory of Child Marriage', Zaki Wahhaj

15/19: 'A fast algorithm for finding the confidence set of large collections of models', Sylvain Barde

15/18: 'Trend Dominance in Macroeconomic Fluctuations', Katsuyuki Shibayama

15/17: 'Efficient estimation with many weak instruments using regularization techniques', Marine Carrasco and Guy Tchuente

15/16: 'High school human capital portfolio and college outcomes', Guy Tchuente

15/15: 'Regularized LIML for many instruments, Marine Carrasco and Guy Tchuente

15/14: 'Agglomeration Economies and Productivity Growth: U.S. Cities, 1880-1930', Alexander Klein and Nicholas Crafts

15/13: 'Microcredit with Voluntary Contributions and Zero Interest Rate - Evidence from Pakistan', Mahreen Mahmud

15/12: 'Act Now: The Effects of the 2008 Spanish Disability Reform', Matthew J. Hill, Jose Silva and Judit Vall

15/11: 'Testing for Level Shifts in Fractionally Integrated Processes: a State Space Approach', Davide Delle Monache, Stefano Grassi and Paolo Santucci de Magistris

15/10: 'German Wage Moderation and European Imbalances: Feeding the Global VAR with Theory', Timo Bettendorf and Miguel A. León-Ledesma