Does labour regulation affect equally technical and allocative efficiency? evidence from the banking industry.

Koutsomanoli A., Kumbhakar C. S. Mamatzakis E. and Tsionas E.

July 2014

Abstract

We focus on disentailing the effect of labour market institutions and regulations on technical and allocative efficiency of banks. We opt for the Fraser index for labour regulation and its disaggregated sub-components, whilst follow a novel methodology to measure performance, based on the seminal work of Kumbhakar and Tsionas (2005), which allows the estimation of technical and allocative efficiency and the examination of the effect of labour market regulations in a single stage. Results indicate the existence of a positive relationship between the liberalization of EU labour markets and allocative efficiency, while the effect on technical efficiency appears to be negative, although not statistically significant. When looking at the disaggregated components of the labour index, we further confirm that different forces are at play. In particular, we find a negative relationship between allocative efficiency and the liberalization of price-related regulations, such as minimum wage and cost of dismissals regulations, while the relationship between technical efficiency and labour regulations that affect banks' ability to adjust their labour input appears to be insignificant.

Keywords: *Labour regulation; banks; technical and allocative efficiency; Maximum Likelihood.*

1. Introduction

Over the past decade, the European banking system has undergone significant structural changes, which have been further precipitated by the financial crisis. As part of this restructuring process, banks have focused their efforts on improving operating performance through a reduction in operating costs and have implemented wide-ranging cost-cutting measures by introducing organizational changes, and reducing both branch networks and the number of employees (ECB, 2003; 2013). Moreover, as a result of the financial and the sovereign debt crisis, the urgency to reduce costs and improve bank efficiency has further increased in the current challenging macroeconomic environment with slow credit growth, high funding costs and increasing non-performing loans. In addition, the crisis has clearly highlighted that the cycle of easy credit of the previous years masked serious underlying problems, such as the build-up of highly complex operating models and high cost structures, including personnel expenses.

Although personnel expenses comprise a relatively small fraction of banks' cost structure compared to other industries, they have been at the centre of bank managers' cost-cutting efforts during the recent years. Data for the EU-15 banking systems from the OECD Bank Profitability Report (2010)[1] suggest that personnel expenses as a share of total cost range from 5 per cent in Luxembourg to about 24 per cent in Greece. Moreover, staff expenses as a per cent of total bank costs were increasing up to 2004 in most countries, reaching about 35% in Greece, and above 25% in Spain, Italy, France and Denmark; however this trend was reversed since 2005. Overall, the data suggest that the rationalization of personnel expenses has been at the centre of managers' cost-reducing efforts in recent years.

Aknowledge: We would like to thank Anastasia Koutsomanoli-Fillipaki for excellent assistanship in preparing this manuscript.

[1] See Figure C1 in the Appendix.

Banks' ability to adjust staff costs and their responsiveness to changing circumstances are highly influenced, among others, by labour institutions and regulations. According to Boeri et al. (2008) labour market regulations can affect firms' choices over inputs, investments, technology and output. At an aggregate level labour regulation also influences the allocation of resources across firms and sectors of the economy, impacting on growth.[2] Bertola, (2009) emphasises the important role of limited wage-setting flexibility, as well as of regulatory constraints on hiring and firing, and of employment protection legislation on labour mobility and thus, on the allocation of a key production input (labour). While a number of studies have examined the impact of labour regulations at a macro level (e.g., Botero et al.,2004; Lazear, 1990), very few microeconomic cross-country empirical studies analyse the impact of labour market rigidities on firm-level outcomes (Lafontaine and Sivadasan, 2007).

The aim of this paper is to fill this gap in the literature and to investigate the effects of labour market regulation on technical and allocative efficiency in the European banking industry over the period 2005-2010. In particular, we propose a new methodology, which builds on Kumbhakar and Tsionas (2005a) and Tsionas and Kumbhakar (2006) that allows us to estimate both technical and allocative efficiencies and to examine the effect of labour regulations in a single stage. We opt for maximum likelihood estimation of technical and allocative efficiency, while allowing errors in the share equations also to be present in the cost function equation.

Our study is related to various strands of the literature. Foremost, this paper relates to the literature on bank efficiency (for a review, see Berger, 2007). A common finding of this literature is the high level of cross-country heterogeneity in the European banking system

[2] The effect of labour market regulations on economic outcomes is the subject of an ongoing debate among economists and policymakers (Boeri et al., 2008). Some argue that regulations affect negatively economic efficiency and therefore are detrimental for growth, while others argue that they are essential tools to correct market imperfections and achieve goals of redistribution without hampering efficiency (see Boeri and van Ours, 2008 for a discussion).

(e.g. Altunbas et al., 2001; Lozano-Vivas et al., 2002; Maudos et al., 2002; Casu and Molyneux, 2003) and the importance of environmental (country-level) variables in explaining cross-country differences in bank efficiency (e.g. Dietsch and Lozano-Vivas, 2000). Among these factors, several studies have focused on the effect of regulation on bank efficiency and have found that banking regulations in particular can have a significant impact on the performance of financial institutions (e.g., Barth et al., 2004; 2009; Pasiouras et al., 2009, Mamatzakis et al. 2013). However, the regulatory framework in other areas of the economy, such as labour legislation, and its effect on bank performance has so far been neglected with the exception of E. Mamatzakis et al. (2013) that focuses on business regulation. This point is particularly emphasized by Demirguc-Kunt et al. (2004), who investigated the impact of a wider set of regulations on bank net interest margins and overhead costs and found that tighter regulations on bank entry and bank activities raise the cost of financial intermediation, but also that bank regulations become insignificant when controlling for national indicators of economic freedom or property rights protection. They conclude that bank regulations cannot be viewed in isolation, as they reflect broad, national approaches to private property and competition. Studies that explicitly focus on the importance of country-level institutional or regulatory quality as determinants of bank efficiency are scarce and include, for example, Lensink et al. (2008), who found that the effect of foreign ownership on bank efficiency depends on the regulatory and institutional framework and Hasan et al. (2009), who examined the impact of institutional quality on the cost and profit efficiency of the banking sector at the regional level in China.

Our study is also related to the literature on labour market regulations. Labour market regulation is the subject of much theoretical work as well as extensive empirical research (Bertola, 2009). In particular, labour market regulations that constrain firms’ ability to adjust employment levels are an important and controversial public policy issue in many countries around the world. The relevant literature has mainly focused on the macroeconomic effects of labour market regulation and its impact on output and unemployment (Lazear, 1990; Blanchard and Wolfers, 2000; Botero et al., 2004; Nickell, 1997; Nickell and Layard, 1999; Heckman and Pages, 2003). More specifically, labour regulations are often cited as a determinant of economic performance in OECD countries (e.g. Freeman, 1988; Nickell and Layard, 1999). It appears that the literature (Freeman, 1988; Blanchard and Wolfers, 2000; Nickell, 1997; Nickell and Layard, 1999; Besley and Burgess, 2004) predominantly suggests that a higher degree of labour market regulation leads to efficiency losses for firms. This is manifested in rising employment costs as a result of stricter employment protection legislation (Bassanini and Ernst 2002; Scarpetta and Tressel 2004, Mamatzakis et al. 2013), which in turn, negatively affects firms' returns with respect to innovation and technology, resulting in declining productivity growth (Malcomson 1997). By contrast, labour market regulations, to the extent that they cause increased wage pressures, could result in higher labour productivity due to capital deepening and investment in capital-intensive industries (Autor et al., 2007).

In this study we try to extend this literature by investigating the microeconomic implications of labour regulation and in particular by examining the effect of labour market regulation on EU bank performance. In more detail, we use a subcomponent of the Fraser Index on Economic Freedom to proxy labour market liberalization and investigate its effect on banks' technical and allocative efficiency. Subsequently, we analyse the impact of the various sub-components of the labour regulation index on allocative and technical efficiency, respectively. This latter stage of analysis is particularly interesting, as price-related labour market regulations are expected to impact on allocative efficiency, while regulations affecting the allocation of the labour input are expected to affect technical efficiency. A first glimpse at the results shows a positive relationship between the liberalization of EU labour markets and allocative efficiency, while on the other hand, the relationship between technical efficiency and the labour market liberalization appears to be negative, although not significant. Furthermore, when disaggregating the labour market regulation index into its components, we find evidence of different forces at play. In particular, the analysis of the sub-components of the labour market regulation index provides evidence that price-related labour market regulations significantly affect bank performance through the channel of allocative efficiency. On the other hand, there appears to be no strong evidence of a significant relationship with technical efficiency.

The rest of the paper is structured as follows: Section 2 presents the methodology, while Section 3 describes the dataset. Section 4 presents the empirical results. Finally, section 5 offers some concluding remarks and possible policy implications.

2. Decomposing efficiency into technical and allocative: a theoretical framework

In this section, we lay out the model proposed in Kumbhakar (1997) and Tsionas & Kumbhakar (2006). Let the production technology be specified as $q_i = f(x_i e^{-u_i})$ where q_i is output and x_i is a vector of J inputs for firm i ($i = 1, \ldots, n$), $f(.)$ is the production function, and $u_i \geq 0$ measures input-oriented (IO) technical inefficiency (Farrell, 1957). This specification implies that a technically inefficient bank over-uses all the inputs by $u \cdot 100$ percent compared to an efficient bank producing the same output. Consequently, the IO measure of technical inefficiency is useful, when the objective of the banks is to allocate inputs in such a way that cost is minimized for an exogenously given level of output. In allocating inputs banks may make mistakes. These mistakes are labelled as allocative inefficiency. Here we follow Schmidt and Lovell (1979) and Kumbhakar (1997) in modelling allocative inefficiency, viz., $f_j(x_i e^{-u_i}) / f_1(x_i e^{-u_i}) = w_{j,i} e^{\xi_{j,i}} / w_{1,i}$, $j = 2,..., J$, where f_j (.) is the marginal product and w_j is the price of input *j*. Here a non-zero value of $\xi_{j,i}$ indicates the presence of allocative inefficiency for the input pair (*j*,1) for firm *i*. Note that unless the production function is homogeneous the IO technical inefficiency term (u) will not drop out from the first-order conditions.

Since $\xi_{j,i}$ represents allocative inefficiency for the input pair (*j*, 1) the relevant input prices to the firm *i* (i = 1, …, n) are $w_i^* \equiv (w_{1,i},\ w_{2,i}\exp(\xi_{2,i}), \ldots, w_{J,i}\exp(\xi_{J,i}))'$, where $\xi_{2,i},...,\xi_{J,i}$ are random variables that capture allocative inefficiency. Kumbhakar (1997) showed that actual cost could be expressed as

$$\ln C_i^a = \ln C^*(w_i^*, q_i) + \ln G(w_i, q_i, \xi_i) + u_i \tag{1}$$

where $C_i^a = \sum_j w_{j,i} x_{j,i}$ and $C^*(w_i^*, q_i)$ is the minimum cost function obtained from solving the following problem: $\min_{x_i e^{-u}} w_i^{*'} x_i e^{-u}$ subject to $q_i = f(x_i e^{-u})$. The $G(w_i, q_i, \xi_i)$ function in (1) is defined as $G(.) = \sum_j S_{j,i}^* e^{-\xi_{j,i}}$, where $S_{j,i}^* = \partial \ln C^*(.) / \partial \ln w_{j,i}^*$. Since (1) is strongly separable in u_i, cost of technical inefficiency (percentage increase in cost due to technical inefficiency) is represented by $u_i \geq 0$. The allocative inefficiency terms (ξ_j) appear both in the $C^*(.)$ and the G(.) functions. Thus, to separate the cost of allocative inefficiency, we need to define $C^0(w_i, q_i)$, the cost frontier (also labeled as the neoclassical cost function). For this, we rewrite the cost function in (1) as $\ln C_i^a = \ln C^0(w_i, q_i) + \ln C^{AL}(w_i, q_i, \xi_i) + u_i$ where $C^0(w_i, q_i)$ is the cost frontier (the neo-classical cost function), which can be obtained from the cost function in (1) by imposing restrictions that firms are efficient both technically and allocatively. That is, $\ln C^0(.) = \ln C^a(. \mid \xi_{j,i} = 0\ \forall\ j, u_i = 0) = \ln C^*(.) \mid \xi_{j,i=0}$ (since $\ln G(.) \mid \xi_{j,i=0} = 0$) and $\ln C^{AL}(w_i, q_i, \xi_i)$ $= \ln C^a \mid_{u_i=0} - \ln C^0(.) = \ln C^*(w_i^*, q_i) + \ln G(w_i, q_i, \xi_i) - \ln C^0(.)$. The $\ln C_i^{AL}$ term can be interpreted as the percentage increase in cost due to allocative inefficiency.

If we assume a parametric functional form (e.g., translog) for $C^*(.)$, i.e.,

$$\ln C^*(w_i^*, q_i) = \alpha_0 + \sum_j \alpha_j \ln w_{j,i}^* + \gamma_q \ln q_i + \tfrac{1}{2}\gamma_{qq} \left(\ln q_i\right)^2 + \tfrac{1}{2}\sum_j \sum_k \beta_{jk} \ln w_{j,i}^* \ln w_{k,i}^* + \sum_j \gamma_{jq} \ln w_{j,i}^* \ln q_i$$

the cost function and the associated cost share equations in terms of $C_0(.)$ are (see Kumbhakar and Tsionas (2005), p. 738)

$$\ln(C_i^a / w_{1,i}) = \ln C_i^0(\tilde{w}_i, q_i) + \ln C_i^{AL}(\tilde{w}_i, q_i, \xi_i) + u_i, \tag{2}$$

$$S_{j,i}^a = S_{j,i}^0(\tilde{w}_i, q_i) + \eta_{j,i}(\tilde{w}_i, q_i, \xi_i),\ \ i = 1, ..., n\,;\ j = 2,\ \dots,\ J \tag{3}$$

where $\tilde{w}_i = (w_{2,i} / w_{1,i}, ..., w_{J,i} / w_{1,i})$, $S_{j,i}^a = w_{j,i}\, x_{j,i} / C_i^a$ is the actual (observed) cost share of input j ($j = 2, ..., J$), $C_i^0(\tilde{w}_i, q_i)$ is the normalized (by $w_{1,i}$) cost frontier and $S_{j,i}^0 = \partial \ln C_i^0(.) / \partial \ln w_{j,i}$ ($j = 2, ..., J$). For the above translog cost function $\ln C_i^0(\tilde{w}_i, q_i)$ is

$$\ln C_i^0(.) = \alpha_0 + \sum_{j=2}^J \alpha_j \ln \tilde{w}_{j,i} + \gamma_q \ln q_i + \tfrac{1}{2}\gamma_{qq}\left(\ln q_i\right)^2 + \tfrac{1}{2}\sum_{j=2}^J \sum_{k=2}^J \beta_{jk} \ln \tilde{w}_{j,i} \ln \tilde{w}_{k,i} + \sum_{j=2}^J \gamma_{jq} \ln \tilde{w}_{j,i} \ln q_i, \tag{4}$$

$$S_{j,i}^0 = \alpha_j + \sum_{k=2}^J \beta_{jk} \ln \tilde{w}_{k,i} + \gamma_{jq} \ln q_i, \quad j = 2, ..., J, \tag{5}$$

$$\ln C_i^{AL} = \ln G_i + \sum_{j=2}^J \alpha_j \xi_{j,i} + \sum_{j=2}^J \sum_{k=2}^J \beta_{jk} \xi_{j,i} \ln \tilde{w}_{k,i} + \tfrac{1}{2}\sum_{j=2}^J \sum_{k=2}^J \beta_{jk} \xi_{j,i} \xi_{k,i} + \sum_{j=2}^J \gamma_{jq} \xi_{j,i} \ln q_i, \tag{6}$$

$$\eta_{j,i} = \frac{S_{j,i}^0 \left\{1 - G_i \exp(\xi_{j,i})\right\} + a_{j,i}}{G_i \exp(\xi_{j,i})}\ , \quad j = 2, ..., J \tag{7}$$

where

$$G_i = \sum_{j=2}^J (S_{j,i}^0 + a_{j,i}) \exp(-\xi_{j,i})\ , \tag{8}$$

and

$$a_{j,i} = \sum_{k=2}^J \beta_{jk} \xi_{k,i}\ . \tag{9}$$

The cost system defined in (2) and (3) serves two purposes. First, technical and allocative inefficiencies are modeled in a coherent manner. Second, the exact link between allocative inefficiency (ξ_j) and its cost is given in (6). The cost function decomposes the overall increase in cost due to inefficiency into two components, viz., the percentage increase in cost due to allocative inefficiency, $\ln C_i^{AL}$, and the percentage increase in cost due to technical inefficiency, u_i. The decomposition formula also establishes an exact link between the error terms in the cost share equations (which are functions of allocative inefficiency) and cost of allocative inefficiency, which is very important from estimation point of view.

In general, the link is provided by the relationship $\ln C^{AL}(w_i, q_i, \xi_i) = \ln C^*(w_i^*, q_i) + \ln G(w_i, q_i, \xi_i)$ $-\ln C^0(.)$. For the Cobb-Douglas case, this link is established in Schmidt and Lovell (1979), viz., $\ln C^{AL} = \sum_{j=2}^{J} \alpha_j \xi_j + \ln\left[\alpha_1 + \sum_{j=2}^{J} \alpha_j e^{-\xi_j}\right] - \ln[\sum_{j=1}^{J} \alpha_j]$. Since Schmidt and Lovell used the system consisting of the production function and the first-order conditions of cost minimization, it was not necessary to use the above link in estimation. It was, however, used to compute the cost of allocative inefficiency.

The crux of the problem is in estimating the cost system in (2) and (3) using the link between cost of allocative inefficiency and errors in the cost share equations (which are functions of allocative inefficiency), given in equations (6), (8) and (9). It can be seen that the error structure based on u and ξ_j in (2) and (3) is quite complicated. Because of this the model has not been estimated using cross-sectional data.[3] In the following section, we discuss an estimation method, first with only allocative inefficiency and then with both technical and allocative inefficiency.

[3] The system described in (2) and (3) is somewhat similar to the panel data model of Kumbhakar and Tsionas (2005a) model which assumed the presence of additional error terms in the share equations. Integrability condition requires that if there are errors in the share equations, these errors should also appear in the cost function (McElroy (1987)). No such allowance was made in the Kumbhakar and Tsionas (2005a) model. Furthermore, they used a Bayesian approach to estimate the system. Here we propose a classical ML method without any extra error terms in the share equations.

2.1 Maximum likelihood estimation

With both technical and allocative inefficiency the system is

$$y_i = X_i\beta + \begin{bmatrix} \ln C^{AL}(\xi_i,\beta) + v_i + u_i \\ \eta(\xi_i,\beta) \end{bmatrix} \equiv X_i\beta + \begin{bmatrix} \zeta_i \\ \eta_i \end{bmatrix} \tag{10}$$

where $u_i \sim i.i.d.N(0,\sigma_u^2)$ $(u_i \geq 0)$ is distributed independently of v_i and ξ_i. The convolution $\omega_i \equiv v_i + u_i$ has a familiar distribution, namely, $f(\omega_i) = \frac{2}{\sigma}\phi\left(\frac{\omega_i}{\sigma}\right)\Phi\left(\frac{\lambda\omega_i}{\sigma}\right)$, where $\sigma^2 = \sigma_v^2 + \sigma_u^2$, $\lambda = \sigma_u / \sigma_v$, and ϕ, Φ denote, respectively the pdf and cdf of the standard normal variable (see Kumbhakar and Lovell (2000), p. 140). Consequently, $p(\zeta_i \mid \xi_i) = p_\omega(\omega_i - \ln C^{AL}(\xi_i,\beta))$.

Assuming $\xi_i \sim i.i.d.N_{J-1}(0,\Omega)$ as before, we obtain the following joint probability density function

$$p(\zeta_i,\eta_i) = p(\zeta_i \mid \eta_i)\cdot p_{\eta}(\eta_i) = p(\zeta_i \mid \xi_i(\eta_i,\beta))\cdot p_{\xi}(\xi_i(\eta_i,\beta)).\lvert \det D\xi_i(\eta_i,\beta)\rvert$$

$$= \tfrac{2}{\sigma}\Phi(\tfrac{\lambda}{\sigma}[\zeta_i - \ln C^{AL}(\xi_i,\beta])\cdot\lvert \det D\xi_i(\eta_i,\beta)\rvert \times$$

$$(2\pi)^{-J/2}\det(\Omega)^{-1/2}\exp\left\{-\frac{[\zeta_i - \ln C^{AL}(\xi_i,\beta)]^2}{2\sigma^2} - \tfrac{1}{2}e(\eta_i,\beta)'\Omega^{-1}e(\eta_i,\beta)\right\}.$$

Using

$$\zeta_i = \ln C_i^a - \ln C_i^0(\beta) - \ln C_i^{AL}(\beta,\xi_i(\eta_i,\beta))$$

$$\eta_{j,i} = S_{j,i}^a - S_{j,i}^0(\beta),\;\; j = 1,\dots,J-1,$$

the likelihood function becomes:

$$L(\beta,\sigma_v,\sigma_u,\Omega;y,X) \propto$$

$$\sigma^{-n}\prod_{i=1}^{n}\Phi(-\tfrac{\lambda}{\sigma}[\zeta_i - \ln C^{AL}(\xi_i,\beta])\cdot\prod_{i=1}^{n}\lvert \det D\xi_i(\eta_i,\beta)\rvert \times$$

$$\det(\Omega)^{-n/2}\exp\left\{-\tfrac{1}{2\sigma^2}\sum_{i=1}^{n}[\zeta_i - \ln C^{AL}(\xi_i,\beta)]^2 - \tfrac{1}{2}\sum_{i=1}^{n}e_i(\eta_i,\beta)'\Omega^{-1}e_i(\eta_i,\beta)\right\}, \tag{11}$$

where $e_i(\eta_i,\beta) = \xi_i(\eta_i,\beta) - \bar{\xi}(\eta_i,\beta)$, and $\bar{\xi}(\eta_i,\beta) = n^{-1}\sum_{i=1}^{n}\xi_i(\eta_i,\beta)$. The above likelihood function can be concentrated with respect to Ω, the ML estimator of which is:

$$\hat{\Omega}(\beta) = n^{-1}\sum_{i=1}^{n} e_i(\eta_i,\beta)e_i(\eta_i,\beta)'.$$

Thus, the concentrated log-likelihood function is proportional to:

$$\ln L^C(\beta,\sigma_v,\sigma_u;y,X) = -\tfrac{n}{2}\ln(\sigma^2) + \sum_{i=1}^{n}\ln\Phi(-\tfrac{\lambda}{\sigma}[\zeta_i - \ln C^{AL}(\xi_i,\beta]) + \sum_{i=1}^{n}\ln|\det D\xi_i(\eta_i,\beta)|$$

$$-\tfrac{n}{2}\det(\hat{\Omega}(\beta)) - \tfrac{1}{2\sigma^2}\sum_{i=1}^{n}[\hat{\zeta}_i - \ln C^{AL}(\xi_i,\beta)]^2. \qquad (12)$$

Here, σ and λ are functions of the original parameters σ_v and σ_u. The model can be generalized so that μ is the mean vector of allocative distortion parameters. This means vector can be made function of a vector of exogenous variables, say z_i, so we have:

$$\mu_i = \Gamma z_i.$$

In this way the exogenous variables have an impact on allocative efficiency, which can be measured easily (e.g. using elasticities) after the parameters have been estimated by the method of ML.

To maximize the log-likelihood functions shown in (12) we use the Nelder-Mead simplex maximization technique that does not require numerical derivatives. To compute standard errors for the parameters we have used the BHHH formula, which is based on first-order derivatives of the log-density with respect to the parameters.

3. Dataset

Bank-level data for the estimation of efficiency are obtained from the Fitch IBCA-Bankscope database and includes commercial, savings and cooperative banks in EU-15 countries

(Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the UK) over the period 2005-2010. After removing errors and related inconsistencies, we end up with a balanced sample of 2,410 banks. For the definition of inputs and outputs we follow Sealey and Lindley (1977) and employ the intermediation approach. The output vector includes loans and other earning assets (government securities, bonds, equity investments, CDs, T-bills, equity investment etc.), while total cost is defined as the sum of overheads (personnel and administrative expenses), interest, fees, and commission expenses. Regarding input prices, the price of labour is proxied by the ratio of personnel expenses to total assets, while the price of deposits is measured by the ratio of total interest expenses to total borrowed funds and the price of physical capital is calculated as the ratio of other operating expenses to fixed assets. Equity is specified as a fixed netput and is included to account for both the risk-based capital requirements and the risk-return trade-off that bank face (Färe et al., 2004).

3.1 Measuring labour market regulation

In order to capture labour market regulations, we employ the Fraser Index of Economic Freedom (Gwartney et. al, 2011) and particularly, one of the five components of the index, namely, labour market liberalization.[4] This indicator quantifies the degree of stringency and distortions associated with existing labour regulations and institutions and provides a synthetic measure of the anti-competitive implications of existing regulations and institutions (European Commission, 2012). The index ranges from 0 to 10, with 0 indicating the lowest and 10 the highest degree of liberalization in the labour market, respectively.

[4] The Fraser Index of Economic Freedom consists of five factors: size of government; legal structure and security of property rights; access to sound money; freedom to exchange with foreigners; and regulation of credit, labour, and business. These are weighted components that form a composite index ranging from 0 to 10, with 0 indicating the lowest and 10 the highest level of economic freedom. The use of this index is common in the economic literature (see for example Carlsson and Lundstrom, 2002).

Over the period 2000-2010 for all EU-15 countries, there is a significant liberalization in European labour markets in all EU countries except Luxembourg. This is not surprising, as the need to improve the functioning of EU labour markets has featured prominently in the priorities of the EU strategy, especially over the last decade. According to the European Commission (2012): '*Since the onset of EMU, there was clear awareness that a successful monetary union would have required reforming labour markets where needed in such a way to ease adjustment in the face of asymmetric shocks and to permit a prompt reaction of price competitiveness as a tool to absorb idiosyncratic shocks and favour the correction of macroeconomic imbalances.*' The need for timely and comprehensive labour market reforms has become even more pertinent in light of the recent sovereign debt crisis in the euro area, especially for countries under IMF/EC/ECB programs. However, there appears to be no clear relationship between the initial conditions of labour market performance and subsequent reform efforts, which is also consistent with the findings of the OECD (Brandt et al., 2005). In addition, according to the European Commission (2012) the distribution of reforms across countries reveals that there is a relatively low degree of cross-country synchronization of reforms over the examined period.

In our analysis, we also employ the sub-components of the Fraser Index on labour regulation over the period 2000-2010. In particular, the index is decomposed into the following factors: i) hiring regulations and minimum wage, ii) hiring and firing regulations, iii) centralized collective bargaining, iv) regulation of hours of work, v) mandated cost of worker dismissal and vi) conscription.[5] Note that the sub-components of the labour regulation index also take

[5] The data used to construct the Fraser Index and its sub-components are from external sources such as the IMF, World Bank, and World Economic Forum that provide data for a large number of countries. These raw data are transformed into component ratings and which are then used to construct the scores. Complete methodological details can be found in the "Economic Freedom of the World: Annual Report 2012". We exclude the 6th sub-

values from 0 to 10, with higher values suggesting greater economic freedom and low values indicating the existence of market rigidities.

In more detail, the first subcomponent of Frazer labour market regulation index, "*hiring regulations and minimum wage*", focuses on the difficulty of hiring and captures some fundamental labour market issues, such as: whether fixed-term contracts allow for permanent tasks, the maximum cumulative duration of fixed-term contracts; and the ratio of the minimum wage for a trainee or first-time employee to the average value added per worker. Looking at Figure 2 (*up left panel*) we observe significant differences across countries, both with regards to the trend of reforms, as well as their direction and their intensity.

The second subcomponent of the Fraser Labour Index is "*hiring and firing regulations*" and captures whether labour market regulations hinder the hiring and firing of workers. Figure 2 (*up right panel*), shows a somewhat slow trend towards greater liberalization in hiring and firing regulations in most countries, suggesting that there may be room for additional liberalization in this area.

The third subcomponent of the Fraser Labour Index is "*centralized collective bargaining*", which refers to country-level industrial relations, and captures whether wages are set by a centralized bargaining process or are left up to each individual company. As we can observe from Figure 2 (*middle left panel*), there are diverging trends across countries, with about half of EU Member States exhibiting a trend towards higher centralization over time.

The fourth subcomponent of the Fraser labour Index, "*hours regulations*" captures various elements including: restrictions on night work; restrictions on weekly holiday work; 5.5 work week; 50 hours or more, including overtime, work week so as to respond to a seasonal increase in production; and 21 working days or fewer paid annual vacation. For most

component of the Fraser Index on labour regulation from our analysis, as we consider it less relevant for the banking system.

countries, but Spain and Greece, we observe a trend towards liberalization over the period 2000-2010.

The “*mandated cost of worker dismissal*” comprises the fifth subcomponent of the Fraser Labour Index and captures the cost of the advance notice requirements, severance payments, and penalties due when dismissing a redundant worker.

3.2 Control Variables

A number of control variables are also included in our analysis in order to account for individual bank characteristics that could affect cost efficiency, such as bank size, credit risk and banks’ net interest margin. In particular, the following variables are included:

Bank Size: Although banks in the EU-15 banking systems have similar organizational structure and objectives, they vary significantly in size. Therefore, we include the logarithm of total assets to account for differences in the size of each bank. Bank size is also a proxy for economies or diseconomies of scale and can lead to either higher or lower costs for banks. If large banks exercise market power, they may increase the costs for the sector through slack and inefficiency. In a similar vein, small banks operating mostly in local markets may have access to “soft” information about local conditions, engage in “relationship lending” and become more efficient than large banks (Berger, 2007). By contrast, if the size of a bank reflects economies of scale and consolidation through the survival of more efficient banks, larger banks may be more cost efficient. Empirical evidence on the relationship between bank size and efficiency is inconclusive (see Altunbas et al., 2001; Carbo et al., 2002; Maudos and De Guevara, 2007).

Credit risk: Managing credit risk is an important part of bank operations. Changes in credit risk may reflect changes in the quality of a bank’s loan portfolio and may affect bank performance. As a proxy for credit risk we use the ratio of loan loss provisions to gross loans. The relationship between inefficiency and credit risk could be positive according to the '*bad management*' or the '*bad luck*' hypotheses developed by Berger and DeYoung (1997), or negative under the '*skimping*' hypothesis.[6]

Net interest margin: Despite the rising importance of fee-based income as a proportion of total income, net interest margins remain one of the principal elements of bank net cash flows and profits. We employ the net interest margin as a traditional measure of bank performance, which captures banks' primary intermediation function, while it also serves as a proxy for bank competition. .

Finally, following the literature, our analysis includes some macroeconomic country-specific variables, namely GDP growth and the inflation rate as proxies for fluctuations in economic activity.

4. Results and Discussion

4.1 Technical and allocative efficiency scores

Table 1 presents the average technical and allocative efficiency scores by country over the period 2005-2010.[7] Our results are in line with the vast majority of the literature that estimates the average cost efficiency of EU countries in the range of 0.80 to 0.85 (see for

[6] Under the '*bad luck*' hypothesis of Berger and DeYoung (1997), exogenous events may cause an increase in a bank's problem loans and the additional managerial effort required to deal with these non-performing loans, will increase bank costs. The '*bad management*' hypothesis assumes that an inefficient bank manager will apply poor senior management practices to both day-to-day operations (increased cost inefficiency) and to managing the loan portfolio (lower credit quality). Under the '*skimping*' hypothesis, a bank may appear more cost efficient in the short run, if it allocates fewer resources to monitoring loans, as less operating expenses can support the same quantity of loans and other outputs.

[7] The average efficiency scores presented in Table 1 are derived from equation (12) using the aggregate labour index to capture labour market regulations and institutions (Table 2 results). Efficiency results derived from the rest of the models presented in this paper (using the sub-components of the aggregate labour index-see tables 3 and 4) are broadly similar and we do not observe any marked sensitivity of the distributions of technical and allocative efficiency. Results are available from the authors upon request.

example Cavallo and Rossi, 2001; 2002; Casu and Girardone, 2004, 2006; Maudos and De Guevara, 2007). Specifically, the average technical efficiency level for all EU-15 countries is estimated at 0.84, ranging from 0.77 in Belgium to 0.92 in Finland. Average allocative efficiency is estimated at 0.89, ranging from 0.86 in Ireland to 0.91 in Finland. Over time (see Figure 1), average technical efficiency remains broadly stable up to 2007 and decreases significantly thereafter, following the advent of the global financial crisis. Technical efficiency improves slightly in 2009 and continues its upward trend also in 2010. Allocative efficiency exhibits a similar trend, showing a clear downward trend after 2007. This trend continues up to 2009, while allocative efficiency starts improving in 2010. Moreover, cross-country analysis reveals similar patterns in the evolution of efficiency scores over time across countries. Looking at the distribution of technical and allocative efficiency over time, we observe (Figure 1) that during the financial crisis (for the years 2008 and 2009) the distribution of both technical and allocative efficiency flattens and moves to the left (to lower efficiency scores). Overall, our efficiency analysis shows that the financial crisis has significantly affected banks' allocative and technical efficiency and that some improvement is observed in 2010, which could reflect banks' increasing efforts to cut down their costs.

(Insert Table 1 and Figures 1 and 2 about here)

Figure 2 presents the distribution of price distortions, across the entire sample, for the prices of borrowed funds (straight line) and labour (dotted line). These parameters are the ξ's in system (2)-(3). The labour price distortion averages approximately 10% and can be as large as about 30-40%. The price distortion of borrowed funds ranges between -20% and 10%, its average is close to -5% and there is clearly some heterogeneity of its distribution across banks –evidenced by the distinct bimodality of the sample distribution. These results indicate that banks effectively face much higher labour costs compared to nominal prices, while most of them buy cheap their borrowed funds. However, there is considerable heterogeneity among banks regarding their funding cost, as evidenced by the sizable probability to the right of zero in the distribution of borrowed fund distortions. The higher heterogeneity in the price of borrowed funds across banks could be explained by differences in banks' business models and by the fact that banks' funding structures differ significantly across countries and across banks of different size and with different institutional characteristics (ECB, 2009).

(Insert Figures 3 and 4 about here)

In Figure 4, we present the sample distributions of price distortions for borrowed funds (upper panel) and labour (bottom panel). We observe that the distributions clearly change over time. For example, after the sub-prime crisis borrowed funds become more expensive, while wage costs decrease from about 10% or 15% in previous periods to about 5% on the average in 2010. This is consistent with the effect of the global financial crisis on banks' funding cost, which has increased significantly, putting an end to a period of ample liquidity observed prior to the crisis (ECB, 2009). Similarly, the ramifications of the financial crisis for executives' compensations and for the financial sector's employees' salaries are possibly evident in the fall in labour costs.

4.2 The impact of aggregate labour regulation index

Table 2 presents the output from estimating Eq. (12) on the relationship between bank efficiency (both technical and allocative) and labour market regulation using the aggregate labour market regulation index.

(Insert Table 2 about here)

Our results indicate that the relationship between labour market liberalization and bank efficiency is complex. On the one hand, we observe a negative relationship between labour market regulation and technical efficiency, which is marginally statistically significant at the

10% level, while on the other hand, the effect of labour market liberalization on allocative efficiency appears to be positive and statistically significant at the 1% level. Overall, the labour economics literature provides mixed evidence with regard to the impact of labour regulation on economic performance (Bassanini et al., 2009). Theoretically, there are several potential ways in which labour market regulation can affect firms' efficiency. From the employers' point of view, increasing employment protection could either improve economic performance by giving incentives to invest in labour-saving technology and innovate, or it could have the opposite effect (Bassanini et al., 2009). From the employees' point of view, higher employment protection might induce workers to invest in firm-specific knowledge, improving their productivity. On the other hand, tenure may reduce employees' motivation to build up specialized skills to increase their productivity.

Our finding of a negative, albeit marginally statistically significant, relationship between technical efficiency and labour market liberalization could reflect one of the above incentives in that labour market liberalization does not offer incentives for the development of firm-specific knowledge and skills, which are important to firm performance (see also Black and Lynch, 1996). Moreover, and specific to the banking sector, a higher degree of labour market liberalization that increases turnover and labour mobility, may negatively impact on *'relationship lending'* in banking, which is based on the personal interaction and relationship between customers and bank employees, thus negatively affecting technical efficiency. In addition, Autor et al., (2007) argue that labour market regulations that enhance wage pressures would induce higher labour productivity due to capital deepening and investment in capital-intensive technologies. This is also consistent with the findings of Storm and Naastepad (2009) showing that at a macro level a regulated and '*rigid*' industrial relations system promotes labour productivity growth in twenty OECD countries. Moreover, Deakin and Sarkar (2008) also showed that labour regulation that strengthens dismissal laws has positive effects on productivity growth in France and Germany, and in the United States over the long term (from the 1970s to mid-2000s). Furthermore, Auer (2007) argues that strict employment protection, and labour market regulation more generally, reduces excessive labour turnover, facilitates the reallocation of resources into activities having above-average productivity growth, and generates high-quality job matches.

On the other hand, we find strong evidence that a higher degree of market liberalization has a positive effect on banks' allocative efficiency. This result is consistent with Lafontaine and Sivadasan (2007), who find a significant impact of labour laws on labour adjustment and related decisions at the micro level. In particular, our finding indicates that in a more liberalized labour market, banks are able to respond more efficiently to changes in the price of labour and to adjust their labour input accordingly. This positive relationship between allocative efficiency and labour market liberalization is also consistent with the findings of Scarpetta and Tressel (2004), who found evidence that high labour adjustment costs (proxied by the strictness of employment protection legislation) can have a strong negative impact on productivity. More specifically, they argue that strict labour market regulations that raise the cost of adjusting factor inputs, including labour, are likely to reduce incentives for innovation and adoption of new technologies, and lead to lower productivity performance (Scarpetta and Tressel, 2004).

Looking at the effect of bank-specific variables on technical and allocative efficiency, our results are consistent with the literature. More specifically, we observe that bank size has a positive effect on both technical and allocative efficiency, while banks with a higher capital ratio exhibit higher technical efficiency, but lower allocative efficiency. The ratio of loan loss provisions to loans, which captures credit risk and the quality of banks' loan portfolio, exhibits a negative relationship with bank technical efficiency, which is consistent with the *'bad management hypothesis'* of Berger and DeYoung (1997), while it has a positive coefficient in the case of allocative efficiency, consistent with the *'skimping hypothesis'* (see Berger and DeYoung, 1997). The net interest margin appears to assert a negative effect on technical efficiency, while it affects positively allocative efficiency. Finally, regarding the macroeconomic variables, we find that the coefficient of GDP growth is only statistically significant in the case of allocative efficiency and takes a positive sign, while inflation appears to have a negative and statistically significant effect.

4.3 The impact of sub-components of labour regulation

As a next step and in order to get a more accurate assessment of the importance of labour market regulation, we decompose the aggregate labour regulation index into its different components, which are, in turn, grouped into two categories. The first category incorporates the indicators with a direct effect on the price of labour (i.e. the minimum wage, the cost of dismissals) that are expected to have an impact on banks' allocative efficiency through their ability to respond to changes in input prices. The second category of indicators includes variables that affect the general institutional setting in the labour market and banks' ability to adjust the input of labour (i.e. hiring and firing regulations, centralized collective bargaining and mandated hours worked) and are expected to have an impact on banks' technical efficiency. Tables 3 and 4 present the estimated results for allocative and technical efficiency, respectively.

(Insert Tables 3 and 4 about here)

Table 3 shows that there is a negative and statistically significant relationship between allocative efficiency and the sub-components of the labour regulation index that affect the price of labour. This relationship is confirmed in all specifications (models 1-3). In particular, we find that the dismissal cost sub-index has a negative and statistically significant effect on allocative efficiency, in line with the findings of Bassanini and Ernst (2002) and Scarpetta and Tressel (2004). According to Cappelli (2000) increased dismissal costs that raise the costs of workforce adjustment, may reduce incentives for firms to expand and innovate, thus affecting their cost performance. In particular, hiring and firing costs increase labour adjustment costs and create disincentives for firms to foster internal efficiency through the adoption of leading technologies and innovation (see e.g., Audretsch and Thurik, 2001).

Moreover, the coefficient for the minimum wage sub-component also asserts a negative and statistically significant effect on allocative efficiency. Our results are consistent with Agell (1999), who argues that significant employment security together with a compressed wage structure stimulates investment in education by workers, with positive effects on their productivity by providing workers with insurance against wage risk. Lower wage risk could also have a positive effect on *'relationship lending'* in banking, thus positively affecting bank efficiency through improved personal relationships between customers and bank employees. Our results are further confirmed when looking at models 2 and 3, where we examine the separate effect of each subcomponent of the labour regulation index. Both the coefficients of the minimum wage sub-component and the dismissal cost sub-index retain their sign and significance. Regarding the remaining bank-specific and macro variables, they all take the expected signs and confirm our previous findings. On the other hand, when looking at the results for technical efficiency (Table 4), we find that the relationship between technical efficiency and the sub-components of the labour regulation index that affect banks' ability to adjust their labour input is not statistically significant in any of the specifications (models 1-4).

These results are of interest as they provide for the first time insights into the relationship between specific aspects of labour regulation and bank performance. In particular, the analysis of the sub-components of the labour market regulation index provides evidence that labour market regulations that affect the price of labour significantly affect bank performance through the channel of allocative efficiency. On the other hand, there appears to be no strong evidence of a significant relationship with technical efficiency.

5. Conclusion

The labour economics literature provides mixed evidence regarding the impact of labour regulation on firm economic performance, whilst the bank performance literature has so far neglected to examine the importance of labour regulation. This paper tries to fill this gap in the literature and examines the impact of labour regulation on technical and allocative efficiency of the EU-15 banking system over the period 2005-2010. In particular, we employ the Fraser index for labour regulation and its sub-components and propose a novel methodology based on the seminal work of Kumbhakar and Tsionas (2005) to investigate the relationship between labour market liberalization and technical and allocative efficiency in European banking.

Overall, our evidence shows that the relationship between bank efficiency and labour market regulation is complex. We find that labour market regulation affects bank efficiency mainly through the channel of allocative efficiency, while its effect on technical efficiency is not significant. More specifically, we find a positive effect of labour market liberalization on allocative efficiency, which is consistent with the findings of Autor et al., (2007) and Lafontaine and Sivadasan (2007). However, when looking at the various sub-components of the labour market regulation index, we find that diverging forces are at play. In particular, we observe that the liberalization of the minimum wage regulations and of the cost of dismissals has a negative effect on allocative efficiency. These findings are consistent with Bassanini and Ernst (2002) and Scarpetta and Tressel (2004), who argue that hiring and firing costs increase labour adjustment costs and create disincentives for firms to foster internal efficiency. Moreover, our results indicate that insurance against wage risk and job security in general, as reflected by a lower level of labour market liberalization, can have a positive effect on *'relationship lending'* in banking, with positive effects on bank efficiency through improved personal relationships between customers and bank employees. Regarding policy implications, our findings clearly demonstrate the complex relationship between efficiency and labour market regulations and the need for policy makers to take this into consideration in the design of labour market reforms.

References

Agell, J., 1999. On the benefits from rigid labor markets: Norms, market failures and social insurance. Economic Journal 108, 143-164.

Altunbas, Y., Gardener, E.P.M., Molyneux, P., Moore, B., 2001. Efficiency in European banking. European Economic Review 45, 1931-1955.

Audretsch, D.B., Thurik, R., 2001. Linking entrepreneurship to growth. OECD STI Working Papers - 2001/2, OECD, Paris.

Auer, P., 2007. In search of optimal labor market institutions. Economic and Labor Market Analysis Papers 3, Geneva: ILO.

Autor, D.H., Kerr, W.R., Kugler, A.D., 2007. Does employment protection reduce productivity? Evidence from US States. Economic Journal 117, 189–217.

Barth, J.R., Caprio, G., Levine, R., 2004. Bank regulation and supervision: What works best? Journal of Financial Intermediation 13, 205-248.

Barth, J.R., Lin, C., Yue, M., Seade, J., Song, F.M., 2010. Do bank regulation, supervision and monitoring enhance or impede bank efficiency? (March 21, 2010). Available at SSRN: http://ssrn.com/abstract=1579352 or http://dx.doi.org/10.2139/ ssrn.1579352

Bassanini, A., Ernst, E., 2002. Labor market regulation, industrial relations and technological regimes. Industrial and Corporate Change 11(3), 391–426.

Bassanini, A., Nunziata, L., Venn D., 2009. Job protection legislation and productivity growth in OECD countries. Economic Policy 58, 349-402.

Berger, A.N., 2007. International comparisons of banking efficiency. Financial Markets Institutions and Instruments 16, 119-43.

Berger, A.N., DeYoung, R., 1997. Problem loans and cost efficiency in commercial banks. Journal of Banking and Finance 21, 849-870.

Bertola, G., 2009. Labor market regulation: Motives, measures, effects. Conditions of Work and Employment Series No. 21, International Labor Office.

Besley, T., Burgess, R., 2004. Can labor regulation hinder economic performance? Evidence from India. Quarterly Journal of Economics CXIX, 91-134.

Black, S.E., Lynch, L.M., 1996. Human-capital investments and productivity. The American Economic Review 86, 263−267.

Blanchard, O., Wolfers, J., 2000. The role of shocks and institutions in the rise of European unemployment: Aggregate evidence. Economic Journal CX, 1-33.

Boeri, T., Helppie B., Macis, M., 2008. Labor regulations in developing countries: A review of the evidence and directions for future research. Social Protection Discussion Papers No. 0833, World Bank.

Boeri, T., van Ours, J., 2008. The Economics of Imperfect Labor Markets. Princeton University Press.

Botero, J.C., Djankov, S., La Porta, R., Lopez-de-Silanes, F., Shleifer, A., 2004. The regulation of labor. Quarterly Journal of Economics 119, 1339-82.

Brandt, N.., Burniaux, J., Duval, R., 2005. Assessing the OECD jobs strategy: Past developments and reforms. OECD Economics Department Working Papers No. 429, OECD Publishing.

Cappelli, P., 2000. Examining the incidence of downsizing and its effect on establishment performance. In D. Neumark (ed.), On the Job, New York: Russell Sage Foundation.

Carbo, S., Gardener, E.P.M., Williams, J., 2002. Efficiency in banking: Empirical evidence from the savings banking sector. The Manchester School 70 (2), 204-228.

Carlsson, F., Lundstrom, S., 2002. Economic freedom and growth: Decomposing the Effects. Public Choice 112, 335-344.

Casu, B., Girardone, C., 2004. Large banks' efficiency in the single European market. The Service Industries Journal 24(6), 129–142.

Casu, B., Girardone, C., 2006. Bank competition, concentration and efficiency in the Single European banking market. The Manchester School 74(4), Special Issue 2006, 441-468.

Casu, B., Molyneux, P., 2003. A comparative study of efficiency in European banking. Applied Economics 35, 1865-1876

Cavallo, L., Rossi, S.P.S., 2001. Scale and scope economies in the European banking systems. Journal of Multinational Financial Management 11, 515–531.

Cavallo, L., Rossi, S.P.S., 2002. Do environmental variables affect the performance and technical efficiency of European banking systems? A parametric analysis using the stochastic frontier approach. The European Journal of Finance 8, 123-146.

Deakin, S., Sarkar, P., 2008. Assessing the long-run economic impact of labor law systems: A theoretical reappraisal and analysis of new time series data. Industrial Relations Journal 39, 453-487.

Demirguc-Kunt, A. Laeven, L., Levine, R., 2004. Regulations, market structure, institutions, and the cost of financial intermediation. Journal of Money, Credit and Banking 36(3), 593 622.

Dietsch, M., Lozano-Vivas, A., 2000. How the environment determines banking efficiency: A comparison between French and Spanish industries. Journal of Banking and Finance 24, 985-1004.

European Central Bank, 2003. Structural analysis of the EU banking sector: Year 2002. ECB, November 2003.

European Central Bank, 2009. EU banks' funding structures and policies. ECB, May 2009.

European Central Bank, 2013. Financial Stability Review. ECB, May 2013.

European Commission, 2012. Labor market developments in Europe 2012. European Economy 5/2012.

Färe, R., Grosskopf, S., Weber, W., 2004. The effect of risk-based capital requirements on profit efficiency in banking. Applied Economics 36, 1731–1743.

Farrell, M.J., 1957. The Measurement of Productive Efficiency. Journal of the Royal Statistical Society 120, 253-81.

Freeman, R.B., 1988. Labor market institutions and economic performance. Economic Policy VI, 64-80.

Gwartney J.D., Hall J.C., Lawson R., 2011. Economic freedom of the world: 2011 Annual Report. Vancouver, BC: The Fraser Institute. Data retrieved from www.freetheworld.com.

Hasan, I., Haizhi, W., Mingming, Z., 2009. Do better institutions improve bank efficiency? Evidence from a transitional economy. Managerial Finance 35, 107-127.

Heckman, J., Pages, C., 2003. Law and employment: Lessons from Latin America and the Caribbean. NBER Working Papers 10129, National Bureau of Economic Research.

Kumbhakar, S.C., 1997. Modeling Allocative Inefficiency in a Translog Cost Function and Cost Share Equations: An Exact Relationship. Journal of Econometrics 76, 351-356.

Kumbhakar, S.C., Lovell, C.A.K., 2000. Stochastic Frontier Analysis. Cambridge University Press, New York.

Kumbhakar, S.C., Tsionas, E.G., 2005. The Joint Measurement of Technical and Allocative Inefficiencies: An Application of Bayesian Inference in Nonlinear Random-Effects Models. Journal of American Statistical Association 100, 736-747.

Kumbhakar, S.C., Tsionas, E.G., 2005a. Measuring Technical and Allocative Inefficiency in the Translog Cost System: A Bayesian Approach. Journal of Econometrics 126, 355-384.

Lafontaine, F., Sivadasan, J., 2007. The microeconomic implications of input market regulations: Cross-country evidence from within the firm. IPC Working Paper Series No. 22, International Policy Center, University of Michigan.

Lazear, E., 1990. Job security provisions and employment. Quarterly Journal of Economics 105, 699-726.

Lensink, R., Meesters, A., Naaborg, I., 2008. Bank efficiency and foreign ownership: Do good institutions matter? Journal of Banking and Finance 5, 834-44.

Lozano-Vivas, A., Pastor, J.T, Pastor, J.M., 2002. An efficiency comparison of European banking systems operating under different environmental conditions. Journal of Productivity Analysis 18, 59-77.

Malcomson, J.M., 1997. Contracts, hold-up and labor markets. Journal of Economic Literature 35, 1917–57.

E. Mamatzakis, A. Kalyvas and J. Piesse, 2013. Does Regulation in Credit, Labour and Business Matter for Bank Performance in the EU-10 Economies? International Journal of the Economics of Business, vol. 20, No. 3.

Maudos, J., Pastor, J.M., Perez, F., Quesada, J., 2002. Cost and profit efficiency in European banks. Journal of International Financial Markets, Institutions and Money 12, 33-58.

Maudos, J., De Guevara, J.F. 2007. The cost of market power in banking: Social welfare loss vs. cost inefficiency. Journal of Banking and Finance 31 (7), 2103-2125.

McElroy, M., 1987. Additive General Error Models for Production, Cost, and Derived Demand or Share System. Journal of Political Economy 95, 738-57.

Nickell, S., 1997. Unemployment and labor market rigidities: Europe versus North America. Journal of Economic Perspectives XI, 55-74.

Nickell, S., Layard, R., 1999. Labor market institutions and economic performance. In: Ashenfelter, O., Card, D., (Eds.), Handbook of Labor Economics, Vol. 3. North Holland, Amsterdam.

OECD, 2010. Bank profitability: Financial statements of banks. OECD banking statistics 2000-2009, OECD Publishing.

Pasiouras, F., Tanna, S., Zopounidis, C., 2009. The impact of banking regulations on banks' cost and profit efficiency: Cross-country evidence. International Review of Financial Analysis 18, 294-302

Scarpetta, S., Tressel, T., 2004. Boosting productivity via innovation and adoption of new technologies: Any role for labor market institutions? World Bank Research Working Paper 3273, Washington, DC: World Bank.

Schmidt, P., Lovell, C.A.K., 1979. Estimating Technical and Allocative Inefficiency Relative to Stochastic Production and Cost Frontiers. Journal of Econometrics 9, 343-66.

Sealey, C., Lindley, J., 1977. Inputs, outputs and a theory of production and cost of depository financial institutions. Journal of Finance 32, 1251-266.

Storm, S., Naastepad, C.W.M., 2009. Labor market regulation and productivity growth: Evidence for twenty OECD countries (1984-2004). Industrial Relations 48, 629-654.

Tsionas, Efthymios & Kumbhakar, Subal, 2006. "Estimation of Technical and Allocative Inefficiencies in a Cost System: An Exact Maximum Likelihood Approach," MPRA Paper 20173, University Library of Munich, Germany.

Wasmer, E., 2006. General vs. specific skills in labor markets with search frictions and firing costs. American Economic Review 96(3), 811-831.

Appendix A: Derivation of the likelihood function in the presence of only allocative inefficiency

Since the error vector is $(\varepsilon_i, \eta_i)'$, for the ML method one has to derive the joint pdf of $(\varepsilon_i, \eta_i)'$ starting from the distributions on v_i and ξ_i. For ML, we need to derive the joint pdf of $(\varepsilon_i, \eta_i)'$, that is $p(\varepsilon_i, \eta_i) = p_{\varepsilon|\eta}(\varepsilon_i \mid \eta_i) p_\eta(\eta_i)$ where $\varepsilon_i \mid \eta_i \sim N(\ln C^{AL}(\xi_i(\eta_i), \beta), \sigma_v^2)$ and $\xi_i(\eta_i)$ is the solution of ξ_i in terms of η_i from $\eta_i = \eta_i(\xi_i, \beta)$. Furthermore, the pdf of $p_\eta(\eta_i)$ can be expressed as

$$p_\eta(\eta_i) = p_\xi(\xi_i(\eta_i)).|\det D\xi_i(\eta_i)|, \tag{A.1}$$

where $D\xi_i(\eta_i)$ is the Jacobian matrix (derivatives of ξ_i with respect to η_i). Therefore, the joint pdf of the error vector in (11) is

$$p(\varepsilon_i, \eta_i) = p_{\varepsilon|\eta}(\varepsilon_i \mid \eta_i) p_\eta(\eta_i) = (2\pi)^{-J/2} (\sigma_v^2)^{-1/2} \det(\Omega)^{-1/2} \times$$
$$\exp\left\{ -\frac{[\xi_i - (\ln C^{AL}(\xi_i(\eta_i)]^2}{2\sigma_v^2} - \tfrac{1}{2} e_i(\eta_i, \beta)' \Omega^{-1} e_i(\eta_i, \beta) \right\} |\det D\xi_i(\eta_i)| \tag{A.2}$$

where $e_i(\eta_i, \beta) = \xi_i(\eta_i, \beta) - \mu$, and μ is the mean vector of allocative distortion parameters.

In practice, to implement the likelihood function based on (A.2) we have to show that (i) ξ can be solved in terms of η, and (*ii*) the Jacobian matrix can be derived analytically. We show these next.

For notational simplicity now we drop the observation index i. The first task is to solve for ξ in terms of η. Note that:

$$\eta_j = S_j^a - S_j^0 = \frac{S_j^0[1 - G\exp(\xi_j)] + \sum_{k=1}^{J} \beta_{jk} \xi_k}{G\exp(\xi_j)}$$

$$\Rightarrow (\eta_j + S_j^0) G \exp(\xi_j) = S_j^0 + \sum_{k=1}^{J} \beta_{jk}\xi_k$$

$$\Rightarrow S_j^a G \exp(\xi_j) = S_j^0 + \sum_{k=1}^{J} \beta_{jk}\xi_k = S_j^0 + \sum_{k=2}^{J} \beta_{jk}\xi_k \ , \ \ j = 1,...,J \ . \tag{A.3}$$

For the last equality we used the normalization $\xi_1 = 0$. The equations in (A.3) can be expressed in ratio form to generate the following system of nonlinear equations,

$$\lambda_j \exp(\xi_j) = \frac{S_j^0 + \sum_{k=2}^{J} \beta_{jk}\xi_k}{S_J^0 + \sum_{k=2}^{J} \beta_{Jk}\xi_k} \ , \ \ j = 2,...,J \ , \tag{A.4}$$

where $\lambda_j = S_j^a / S_1^a$. In Appendix B we use fixed point arguments to show that a solution of ξ_j exists and is unique. Once the ξ_j s are obtained, the value of G can be obtained as $G = \frac{S_1^0 + \sum_{k=2}^{J} \beta_{1k}\xi_k}{S_1^a} = \frac{S_1^*}{S_1^a}$. Note that we need G to compute $\ln C^{AL}(\xi_i, \beta)$.

The second task is to derive the Jacobian of the transformation from ξ to η. To compute it we start again from the definition of η_j, i.e.,

$\eta_j = \frac{S_j^0(1-h_j) + \sum_{k=2}^{J} \beta_{ik}\xi_k}{h_j}$, $j = 2,...,J$, where $h_j = G\exp(\xi_j)$. Differentiating it with respect to η_l gives:

$$h_j \delta_{jl} + S_j^a \sum_k \frac{\partial h_j}{\partial \xi_k} \frac{\partial \xi_k}{\partial \eta_l} = \sum_k \beta_{jk} \frac{\partial \xi_k}{\partial \eta_l} \ , \tag{A.5}$$

where δ_{jl} is the Kronecker delta. The system in (A.5) can be written as:

$$\Theta D = M \ , \tag{A.6}$$

where $\Theta_{jk} = S_j^a \frac{\partial h_j}{\partial \xi_k} - \beta_{jk}$, $D_{kj} = \frac{\partial \xi_k}{\partial \eta_j}$, $M = -diag(h_2,...,h_J)$. Here, D (the short form of $D\xi_j(\eta_j)$) is the Jacobian of the transformation. The solution of D from (A.6) is $D = \Theta^{-1}M$, and $\det(D) = \det(\Theta)^{-1}\prod_{j=2}^{J} h_j$. To evaluate the components of Θ we obtain

$$\frac{\partial h_j}{\partial \xi_k} = \left(\frac{\partial G}{\partial \xi_k} + G\delta_{jk}\right)\exp(\xi_j), \quad j,k = 2,...,J,$$

$$\frac{\partial G}{\partial \xi_k} = \sum_m \beta_{km}\exp(-\xi_m) - \exp(-\xi_k)S_k^*, \quad k = 2,...,J,$$

with the understanding that all the previous expressions are evaluated at the solution of the system which is $\xi = \xi(\eta)$. Thus, the solution for the ith observation can be written as $\xi_i = \xi_i(\eta_i, \beta)$, and the likelihood function is

$$\begin{aligned} &L(\beta, \sigma_v, \Omega; y, X) = (2\pi)^{-Jn/2}(\sigma_v^2)^{-n/2}\det(\Omega)^{-n/2} \times \\ &\exp\left\{-\tfrac{1}{2\sigma_v^2}\sum_{i=1}^{n}[\varepsilon_i - \ln C^{AL}(\beta, \xi_i(\eta_i, \beta)]^2 - \tfrac{1}{2}\sum_{i=1}^{n} e_i(\eta_i, \beta)'\Omega^{-1}e_i(\eta_i, \beta)\right\}\prod_{i=1}^{n}|\det D\xi_i(\eta_i, \beta)| \end{aligned} \tag{A.7}$$

where $e_i(\eta_i, \beta) = \xi_i(\eta_i, \beta) - \mu$.

The ML estimators of σ_v^2, μ and Ω are:

$$\tilde{\sigma}_v^2(\beta) = n^{-1}\sum_{i=1}^{n}[\varepsilon_i - (\ln C^{AL}(\xi_i(\eta_i, \beta))]^2, \quad \tilde{\mu}(\beta) = n^{-1}\sum_{i=1}^{n}\tilde{\xi}_i(\beta) \equiv \bar{\xi}(\beta),$$

$$\tilde{\Omega}(\beta) = n^{-1}\sum_{i=1}^{n}[\tilde{\xi}_i(\beta) - \bar{\xi}(\beta)][\tilde{\xi}_i(\beta) - \bar{\xi}(\beta))]',$$

where $\tilde{\xi}_i(\beta) \equiv \xi_i(\tilde{\eta}_i, \beta)$, and $\tilde{\eta}_i$ is the cost share residual vector. In fact, in this study we want to make allocative inefficiency function of a vector of exogenous variables, say z_i, so we have:

$$\mu_i = \Gamma z_i,$$

and we do not use the estimator $\tilde{\mu}(\beta)$; therefore, we have $\bar{\xi}(\beta) \equiv \bar{\xi}_i(\beta) = \mu_i$.

The concentrated log-likelihood function is:

$$\ln L^C(\beta; y, X) = \text{const.} - (n/2)\ln\tilde{\sigma}_v^2(\beta) - (n/2)\ln(\det(\tilde{\Omega}(\beta))) + \sum_{i=1}^{n}\ln|\det D\xi_i(\bar{\eta}_i, \beta)|. \tag{A.8}$$

Appendix B: Existence and uniqueness of solution to the system of equations

Theorem: If (B1) the actual share $S_i^a > 0$ for all $i \in \mathbf{Z} = \{1,..., J\}$, (B2) for every $i \in \mathbf{Z}$, we have ($\beta_{ij} \neq 0$ for some $j \in \mathbf{Z}$), where β_{ij} represents the second-order translog coefficients with respect to prices, (B3) $\sum_{j\in\mathbf{Z}} \beta_{jk} = 0$, and (B4) $\sum_{j\in\mathbf{Z}} S_j^0 = 1$, then (i) there exists a solution of ξ in the system of equations in (14), and (ii) the solution is unique.

Proof: Before proving the existence and uniqueness, we note that the condition in (B1) follows from the definition of cost shares, while that in (B2) is necessary for flexibility of the translog cost function. Finally, the conditions (B3) and (B4) follow from homogeneity (of degree one in input prices) of the cost function.

(i) Existence.

The system in (14) is of the form $S_j^a \exp(\xi_j) G = S_j^0 + \sum_{k\in\mathbf{Z}} \beta_{jk}\xi_k$, $j \in \mathbf{Z}$. Note that here we are considering the system in which the homogeneity restrictions are not directly imposed by expressing all prices and cost relative to one input price. Let $\kappa_j = S_j^a \exp(\xi_j) G$, $j \in \mathbf{Z}$, so that $\ln \kappa_j = \ln S_j^a + \xi_j + \ln G$, $j \in \mathbf{Z}$. Then the system in (14) can be written in the form

$$\kappa_j = S_j^0 - \sum_{k\in\mathbf{Z}} \beta_{jk} \ln S_k^a + \sum_{k\in\mathbf{Z}} \beta_{jk} \ln \kappa_k - \ln G \sum_{k\in\mathbf{Z}} \beta_{jk} = S_j^0 - \sum_{k\in\mathbf{Z}} \beta_{jk} \ln S_k^a + \sum_{k\in\mathbf{Z}} \beta_{jk} \ln \kappa_k \ , \ j \in \mathbf{Z} . \qquad \text{(B.1)}$$

such that $\sum_{j\in\mathbf{Z}} \kappa_j = 1$. Then $\kappa \in \mathrm{S} \equiv \{\kappa \in \mathbb{R}_+^n \mid \sum_{j\in\mathbf{Z}} \kappa_j = 1\}$, the unit simplex in $\mathbb{R}^n$. Write the residual from the cost share system (3) as:

$$f_j(\kappa) = \kappa_j - S_j^0 + \sum_{k\in\mathbf{Z}} \beta_{jk} \ln S_k^a - \sum_{k\in\mathbf{Z}} \beta_{jk} \ln \kappa_k \ , \ j \in \mathbf{Z} . \qquad \text{(B.2)}$$

Define the mapping:

$$g_j(\kappa) = \frac{\kappa_j + f_j(\kappa)^2}{1 + \sum_{k\in\mathbf{Z}} f_k(\kappa)^2}, \ j \in \mathbf{Z} .$$

Clearly, $g : \mathrm{S} \to \mathrm{S}$, i.e., it maps S into itself and is continuous. By Brouwer's fixed point theorem, there exists a $\kappa^* \in \mathrm{S}$ such that $g(\kappa^*) = \kappa^*$, which implies that:

$$f_j(\kappa^*)^2 = \kappa_j^* \sum_{k\in\mathbf{Z}} f_k(\kappa^*)^2 , \ j \in \mathbf{Z} .$$

Multiplying both sides by $f_j(\kappa^*)$ and summing over j we obtain:

$$\sum_{j\in\mathbf{Z}} f_j(\kappa^*)^3 = \sum_{j\in\mathbf{Z}} \kappa_j^* f_j(\kappa^*) \sum_{k\in\mathbf{Z}} f_k(\kappa^*)^2 .$$

Suppose $f_j(\kappa^*) = 0$ for all $j \neq l$ but $f_l(\kappa^*) \neq 0$. Then the above equation implies $f_l(\kappa^*)^3 = \kappa_l^* f_l(\kappa^*)^3$, which gives $\kappa_l^* = 0$. Write $\kappa_l^* = S_l^a \exp(\xi_l^*)$. By assumption (B1) since $\kappa_l^* = 0$ we have $\xi_l^* = -\infty$. For $\kappa_l^* = 0$ by (B.2) we obtain $f_j(\kappa^*) = \pm\infty$ for some $j \in \mathbf{Z}$ provided assumption (B2) holds. Now, $g_l(\kappa^*) = \kappa_l^* = \dfrac{\kappa_l^* + f_l(\kappa^*)^2}{1 + f_l(\kappa^*)^2}$. Although $\kappa_l^* = 0$, the limit of the right hand side expression as $\kappa_l^* \to 0$ (and therefore as $f_l(\kappa^*)^2 \to +\infty$) is equal to one, a contradiction since $g_l(\kappa)$ is continuous. Therefore, we conclude that at the fixed point κ^* we must have $f_j(\kappa^*) = 0$ for all $j \in \mathbf{Z}$ which means that κ^* represents a solution.

(ii) Uniqueness.

Suppose $\{\xi_j\}$ and $\{\varphi_j\}$ are distinct solutions. Therefore they must satisfy:

$$S_j^a \exp(\xi_j) G = S_j^0 + \sum_{k\in\mathbf{Z}} \beta_{jk} \xi_k$$

$$S_j^a \exp(\varphi_j) G = S_j^0 + \sum_{k\in\mathbf{Z}} \beta_{jk} \varphi_k , \tag{B.3}$$

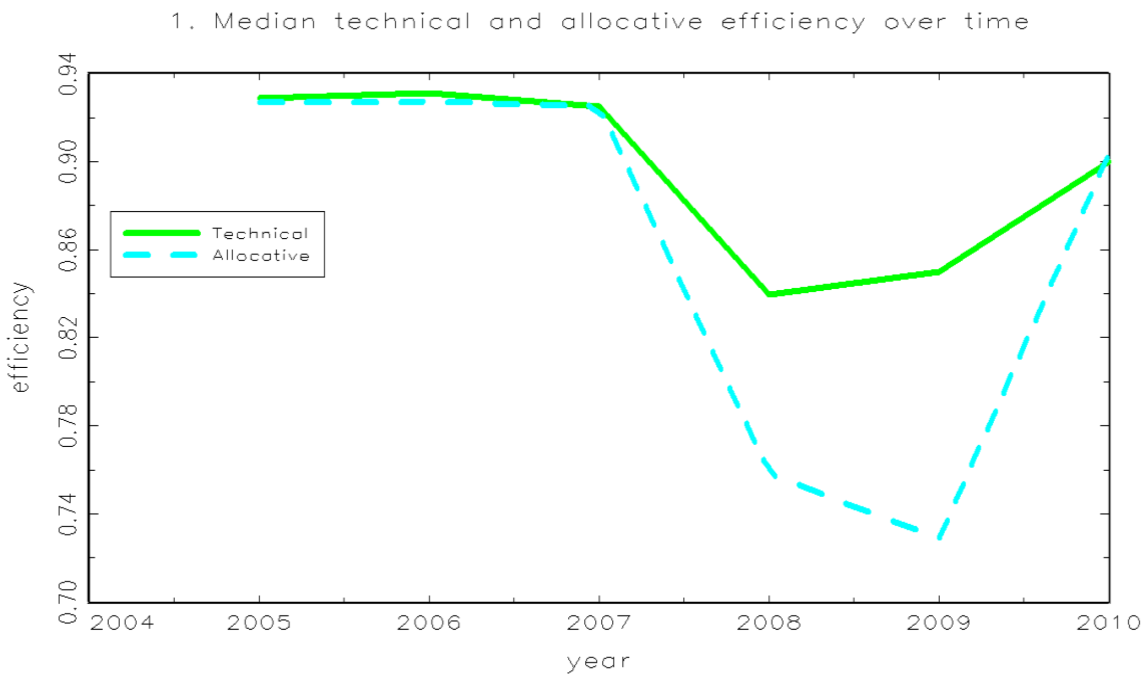
for all $j \in \mathbf{Z}$, and they also satisfy the following equality:

$$\sum_{j\in\mathbf{Z}} S_j^a \exp(\xi_j) = \sum_{j\in\mathbf{Z}} S_j^a \exp(\varphi_j) = 1. \tag{B.4}$$

Define $\varepsilon_k = \xi_k - \varphi_k$ so that we have $S_j^a \exp(\varphi_j)[\exp(\varepsilon_j - 1)] = \sum_{k\in\mathbf{Z}} \beta_{jk}\varepsilon_k$. Let $\Lambda_j = S_j^a \exp(\varphi_j)$ and notice that $\exp(\varepsilon_j - 1) \geq \varepsilon_j$ to obtain $\sum_{k\in\mathbf{Z}} \beta_{jk}\varepsilon_k \geq \Lambda_j \varepsilon_j$. This system can be written in the form $[B - diag(\Lambda)]\varepsilon \geq 0$. Now choose a vector c such that $c'\varepsilon < 0$, which is always possible provided not all the ε_j s are zero (a fact that we have to accept since we have assumed the existence of two different solutions). By applying the Farkas' lemma we obtain that since the above system has a solution, the system $[B - diag(\Lambda)]\varepsilon = c$, $\varepsilon \geq 0$ must have no solution. Therefore, there exists no nonnegative vector ε to satisfy $\sum_{k\in\mathbf{Z}} \beta_{jk}\varepsilon_k = \Lambda_j \varepsilon_j + c_j$. We set $\varepsilon_j = w$ for all j so we know that there exists no nonnegative w to satisfy $c_j = -w\Lambda_j$. We will obtain an obvious contradiction provided we can show that the inequality $c'\varepsilon < 0$ is satisfied. But $c'\varepsilon = \sum_{j\in\Box} c_j \varepsilon_j = -\sum_{j\in\Box} w^2 \Lambda_j < 0$ since the Λ_j s are positive. The contradiction shows that the solution must be unique.

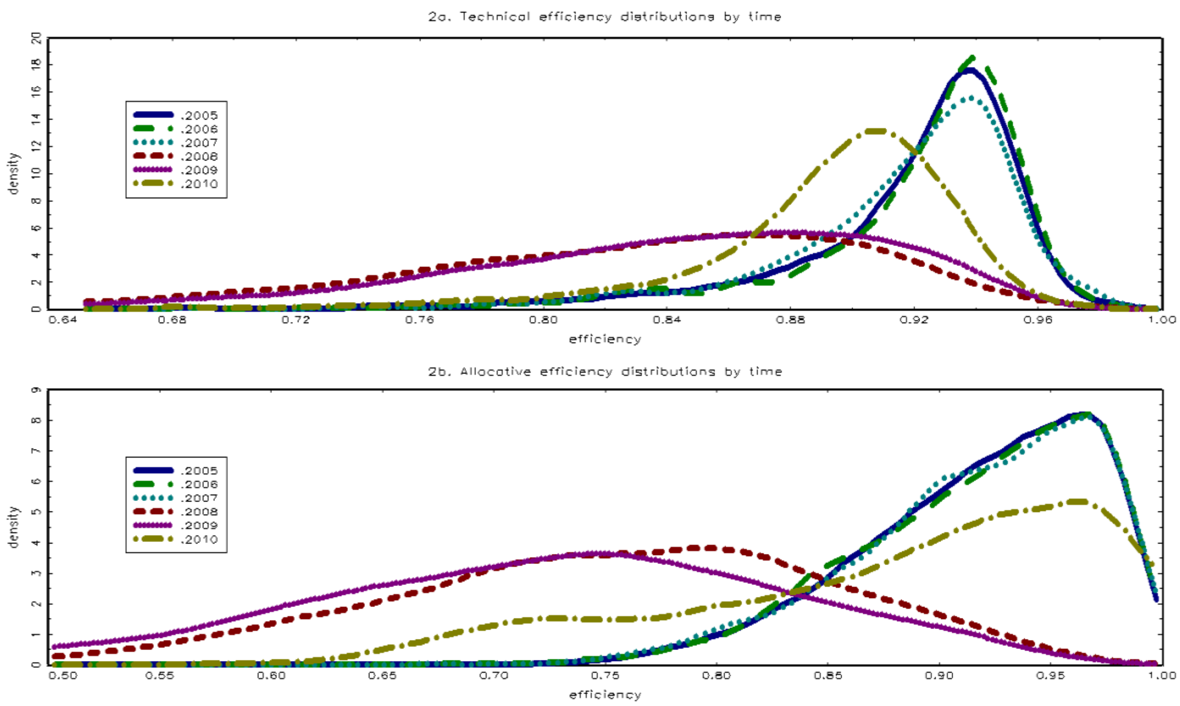
Farkas' lemma: The system $Ax = c$, $x \geq 0$ has no solution if and only if the system $A'y \geq 0$, $c'y < 0$ has a solution.

Figure 1: Technical and allocative efficiency in the EU (2005-2010)



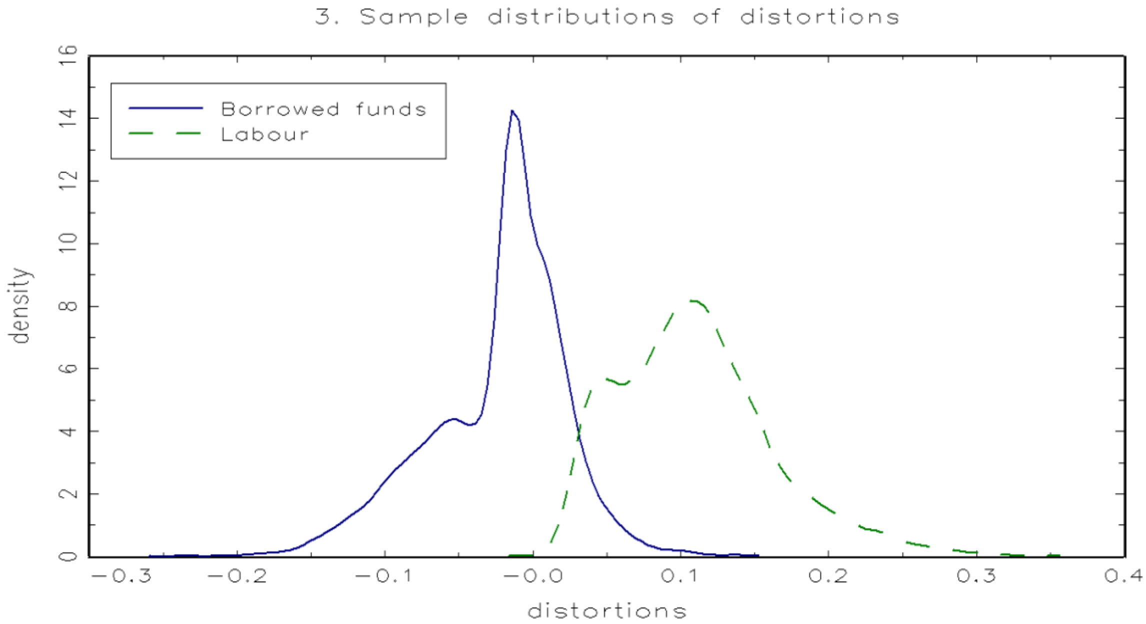
Note: Authors' estimations, median efficiency scores are reported.

Figure 2: Technical and allocative efficiency in the EU by time.



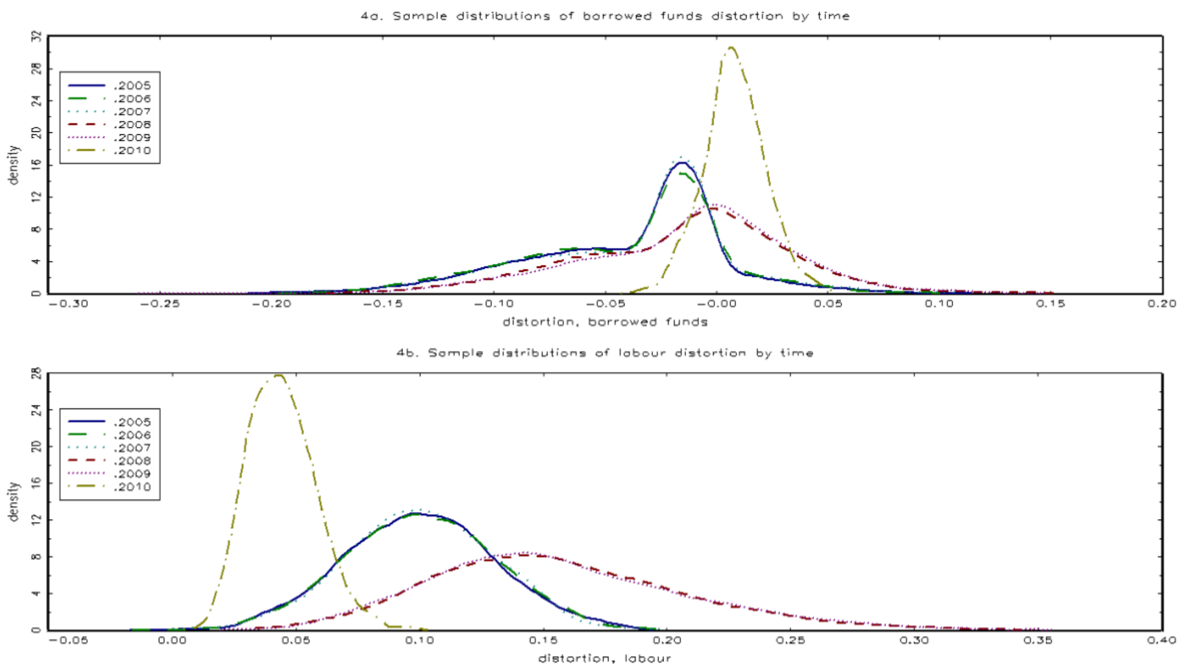
Note: Authors' estimations.

Figure 3: Sample distributions of distortions of inputs



Note: Authors' estimations.

Figure 4: Sample distributions of input price distortions over time



Note: Authors' estimations.

Table 1: Technical and allocative efficiency scores

	TEFF	AEFF
Austria	0.8817	0.8933
Belgium	0.7662	0.8971
Denmark	0.8710	0.8927
Finland	0.9192	0.9140
France	0.8629	0.8900
Germany	0.8843	0.8926
Greece	0.8041	0.8775
Ireland	0.8020	0.8626
Italy	0.8888	0.8763
Lux.	0.8006	0.8928
Netherlands	0.8335	0.8978
Portugal	0.8460	0.8810
Spain	0.8374	0.8725
Sweden	0.8155	0.8978
UK	0.8204	0.8869
EU-15	**0.8422**	**0.8883**

Note: Authors' estimations. Figures are in means over the period 2005-2010. TEFF: Technical Efficiency; AEFF: Allocative Efficiency.

Table 2: Technical and allocative efficiency and aggregate labour market regulation

	TECHNICAL EFF	ALLOCATIVE EFF
constant	0.517***	0.617***
	(0.0156)	*(0.0441)*
LR	-0.073*	0.256***
	(0.04)	*(0.0217)*
GDPgr	0.00416	0.0202***
	(0.0177)	*(0.000151)*
INFL	-0.0036	-0.03313***
	(0.0021)	*(0.00187)*
lnTA	0.0044*	0.0003***
	(0.0023)	*(0.00011)*
NIM	-0.0015***	0.0033***
	(0.00018)	*(0.0012)*
EQ/A	0.0017***	-0.00015***
	(0.00022)	*(0.00001)*
LLP/L	0.0015***	-0.0026***
	(0.00022)	*(0.00019)*

Note: ***, ** and * indicate 1%, 5% and 10% significance levels respectively. S.E. are in parentheses. Standard errors are derived from the sandwich estimator of the covariance matrix of the ML estimator.

Table 3: Allocative efficiency and labour market regulation (disaggregated)

	(1)	(2)	(3)
constant	0.874***	0.877***	0.881***
	(0.00415)	(0.0315)	(0.0182)
MW-FR	-0.0554***	-0.0447***	
	(0.00718)	(0.0042)	
DISS-FR	-0.0570***		-0.0628***
	(0.00414)		(0.0025)
GDPgr	0.0116***	0.0116***	0.0255***
	(0.0005)	(0.00011)	(0.00035)
INFL	-0.032***	-0.0295***	-0.0305***
	(0.0033)	(0.0023)	(0.0044)
lnTA	0.000337	0.000393***	0.00142***
	(0.0002)	(0.000102)	(0.00036)
NIM	0.00281	0.00285***	0.00151***
	(0.0027)	(0.000262)	(0.00042)
EQ/A	-0.0004***	-0.00025***	-0.00044***
	(0.0001)	(0.00001)	(0.00003)
LLP/L	-0.0025***	-0.00261***	-0.00355***
	(0.00022)	(0.00022)	(0.00027)

Note: ***, ** and * indicate 1%, 5% and 10% significance levels respectively. S.E. are in parentheses. Standard errors are derived from the sandwich estimator of the covariance matrix of the ML estimator.

Table 4: Technical efficiency and labour market regulation (disaggregated)

	(1)	(2)	(3)	(4)
constant	0.661***	0.681***	0.681***	0.6723***
	(0.0241)	*(0.0177)*	*(0.0177)*	*(0.0163)*
HF-FR	0.0215	0.0088		
	(0.218)	*(0.117)*		
CCB-FR	0.0145		0.061	
	(0.118)		*(0.125)*	
HR-FR	0.0230			0.0214
	(0.0491)			*(0.337)*
GDPgr	0.00335	0.0032	0.0029	0.0032
	(0.0227)	*(0.0454)*	*(0.0388)*	*(0.0215)*
INFL	-0.0035	-0.0041	-0.0038	-0.0035
	(0.0454)	*(0.171)*	*(0.161)*	*(0.177)*
lnTA	0.00361	0.00291	0.00117	0.00128
	(0.0447)	*(0.220)*	*(0.181)*	*(0.100)*
NIM	-0.00143	-0.0016	-0.0019	-0.0021
	(0.0187)	*(0.0841)*	*(0.0723)*	*(0.0815)*
EQ/A	0.002157***	0.00313	0.0022	0.0025
	(0.00011)	*(0.0185)*	*(0.0140)*	*(0.0217)*
LLP/L	0.00154***	0.00150	0.00162	0.00155
	(0.0008891)	*(0.116)*	*(0.202)*	*(0.335)*

Note: ***, ** and * indicate 1%, 5% and 10% significance levels respectively. S.E. are in parentheses. Standard errors are derived from the sandwich estimator of the covariance matrix of the ML estimator.