Assessing dynamic efficiency of the Spanish construction sector pre- and post-financial crisis

Magdalena Kapelko[a,*], Alfons Oude Lansink[b], Spiro Stefanou[c]

[a] Department of Business Administration, Universidad Carlos III de Madrid, Calle Madrid 126, 28903 Getafe (Madrid), Spain, tel.: +34916249629, fax: +34916249607, e-mail: mkapelko@emp.uc3m.es

[b] Business Economics Group, Wageningen University, Hollandseweg 1, 6706 KN Wageningen, Netherlands, e-mail: Alfons.OudeLansink@wur.nl

[c] Department of Agricultural Economics and Rural Sociology, Penn State University, 208B Armsby Building, University Park, PA 16802, USA and Business Economics Group, Wageningen University, Hollandseweg 1, 6706 KN Wageningen, Netherlands, e-mail: ttc@psu.edu

*Corresponding author.

Abstract: This paper estimates dynamic efficiency in the Spanish construction industry before and during the current financial crisis over the period 2001-2009. Static efficiency measures are biased in a context of a significant economic crisis with large investments and disinvestments as they do not account for costs in the adjustment of quasi-fixed factors. The results show that overall dynamic cost inefficiency is very high with technical inefficiency being the largest component, followed by allocative and scale inefficiency. Moreover, overall dynamic cost inefficiency is significantly larger before the beginning of the financial crisis than during the financial crisis. Results also show that larger firms are on average less technically and scale inefficient than smaller firms, but have more problems in choosing the mix of inputs that minimizes their long-term costs. Firms that went bankrupt, on average have a higher overall dynamic cost inefficiency and scale inefficiency than firms that did not go bankrupt.

Keywords: dynamic efficiency; construction sector

1. Introduction

A competitive sector often depends on its firms meeting their production potential and minimizing waste. Focusing on the growth in returns to factors employed, more competitive firms are able to attract resources away from less competitive firms. Sustaining competitiveness over the long run involves attention to growth prospects associated with the innovations needed to keep pushing the competitive envelope, and the efficiency gains needed to ensure that implemented technologies can succeed. The construction sector in both emerging and mature economies is a classic case in point. In most cases, the expansion a nation's economic fortunes are fueled by the construction sector. The sector draws on a significant capital base as well as being an economy's significant employer and an important contributor to the nation's GDP.

Spain has the largest construction sector among the EU countries (Eurostat). Until very recently, the Spanish construction sector enjoyed a period of constant growth, reaching a 10% share of national GDP in 2006, which is twice the overall comparable figure for the EU, and employing 2.9 million persons (13% of the labor force). During the last decade, the expansion of this industry was a driving force behind the Spanish economic growth. Until 2007, Spain was recording higher annual new home construction completions than France, Germany and Italy combined. In the face of rising interest rates, oversupply, oversize, stricter lending conditions, and the emerging global financial crisis, Spain's construction industry collapsed in 2007 with many firms exiting the sector (Spanish Ministry of Public Works and Transport; Bielsa and Duarte, 2010). The construction downturn negatively impacted on both output and employment and both of them contracted by about one third through the end of 2009 (Eurostat). Given this sector's central role in promoting Spain's competitiveness and economic growth, this study focuses on the construction sector's economic performance.

Figure 1 presents the pattern of construction permits granted and construction completion between 2001 and 2010. The emerging crisis is clearly foretold during 2006 by the building permits granted which is a leading economic indicator of macroeconomic performance. Conversely, the pattern of construction completion presents a lagging indicator of economic performance. Several economic policy levers are available to stimulate this sector's economic activity. Examples include monetary policy impacting interest rates changes, banking policies that can impact mortgage activity, zoning regulation, investment in amenities complementing building activities (such as green space, entertainment opportunities).

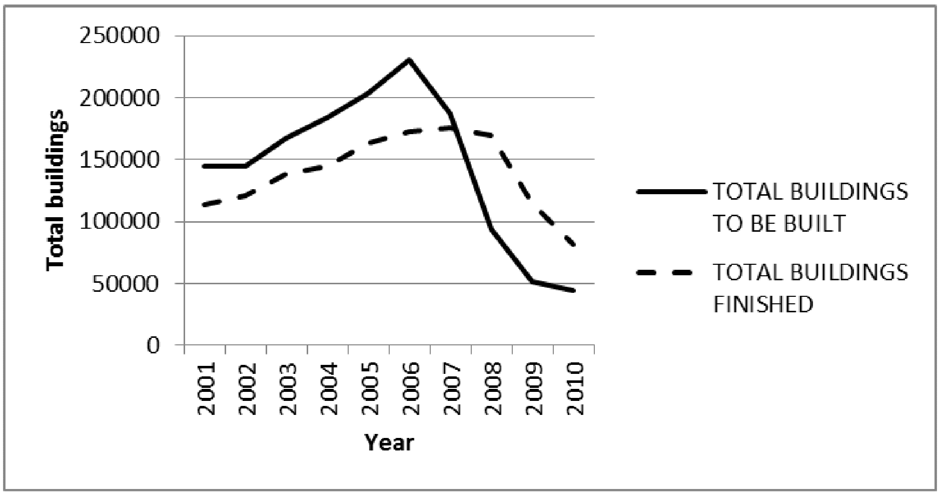

Fig.1. Pattern of construction starts and finishing rates.
Source: elaborated based on the information from the Spanish Statistical Office

The economic performance of the construction sector is the focus of considerable work. Using a growth accounting approach with country level data, Abdel-Wahab and Vogl (2011) compare the Germany, France, UK, USA and Japan constructions sectors over 1990-2005. These analyses suggest this sector growth lags behind the growth in all industries, with Germany and Japan presenting negative growth rates in construction. Li and Liu (2010) find the productivity of the Australian construction sector over 1990-2007 is modest at 1.1%; however, wide fluctuations are observed over time and by different Australians states. In contrast, productivity growth in the Chinese construction sector presents wide differences across regions with an industry average of 4.25% annually (except for the 2001-2002 period which presents an unexplained anomaly) (Xue, et al., 2008).

Country studies report a wide range of efficiency levels employing production- and financial-based frameworks. These range from a low of around 50% for Canadian firms (Pilateris and McCabe, 2003), approximately 60% for Portuguese firms (Horta et al., 2012), to higher estimates of 93% for Greek firms (Tsolas, 2011) and 98% for Chinese firms (Xue et al., 2008). The case of Korea in the late 1990s presents an interesting case in contrast to the Spanish case. The Korean construction sector was impacted by an economic crisis in November 1997. Using a Data Envelopment Analysis (DEA) approach for the period 1996-2000, You and Zi (2007) focus on leverage ratio, export weight, institutional ownership, asset size and receivables overdue turnover and find these factors impact all efficiency measures. However, the declining allocative inefficiency is the major component leading to lower efficiency over the crisis suggesting the agency problem between managers and owners is at fault.

The literature on efficiency traditionally focuses on the static efficiency measures and only recently we observe a number of important contributions on dynamic efficiency modeling with applications to the agricultural/food and energy sectors (Rungsuriyawiboon and Stefanou, 2007; Silva and Stefanou, 2007; Serra et al., 2011). Being a capital intensive sector, the Spanish construction industry presents an interesting case study for dynamic inefficiency analysis in the period before and during a significant economic crisis. Static measures are biased in a context with large investments and disinvestments as they do not account for adjustment costs.

Against this background, the objective of this paper is to assess dynamic cost, technical, allocative and scale inefficiencies in the Spanish construction industry before and during the current crisis and to compare results for different size classes as well as firms that are active and that disband in the time-period considered. With the construction sector being heavily embodied in capital, the adjustment of these stocks is sluggish and cannot be expected to change instantaneously to revised long-run equilibrium levels that come about from the changing macroeconomic environment.

The paper proceeds with the next section presenting the conceptual model based on the intertemporal cost minimization and the presentation of the dynamic cost efficiency measures, followed by the description of the database of financial accounts of Spanish construction firms. The section to follow presents the results comparing the efficiency patterns by different size of firms and firms that are active and that disband, and the decomposition of efficiency. The final section offers concluding comments and some potential policy implications.

2. Conceptual model

Consider a data series representing the observed quantities of M outputs (y), N variable inputs (x), F investments (I) and quasi-fixed factors (K) and N, and F prices of variable and quasi-fixed factors (w and c) of $j = 1,..,J$ firms at time t. At any base period $t \in [0,+\infty)$, the firm is assumed to minimize the discounted flow of costs over time subject to an adjustment-cost technology. The intertemporal cost minimization problem is given by:

$$W(k,w,c,y)=\min_{x,I}\int_{t_o}^{\infty} e^{-es}\left[w_s' x_s + c_s' K_s\right] ds$$

$$\text{s.t.} \qquad (1)$$

$$\dot{K}=I-\delta K, K(t_o)=k$$

$$\vec{D}_i(y(s),K(s),x(s),I(s);g_x,g_I)\geq 0,\ \ s\in[t,+\infty)$$

where *W(·)* represents the discounted flow of costs in all future time periods. The subscript *s* denotes the (future) time periods; subscripts of variables have been suppressed if they represent the current time period *t*. The directional distance function $\vec{D}_i(\cdot)$ measures the distance of *x* and *I* to the frontier in the direction defined by the directional vectors g_x and g_I, respectively.

Expressing (1) in terms of the current value gives the Hamilton-Jacobi-Belman equation:

$$\begin{aligned} rW(y,K,w,c) &= \min_{x,I,\gamma}\left[w'x+c'K+W_K'(I-\delta K)\right] \\ &\text{s.t.} \qquad (2) \\ &\vec{D}_i(y,k,x,I;g_x,g_I)\geq 0, \end{aligned}$$

where $W_K = W_K(y,K,w,c)$ is the vector of shadow values of quasi-fixed factors. Note that the shadow value of quasi-fixed factors is determined endogenously in the model. Equation (2) is represented by the following DEA model:

$$\begin{aligned} rW(y,K,w,c) &= \min_{x,I,\gamma}\left[w'x+c'K+W_K'(I-\delta K)\right] \\ &\text{s.t.} \\ &\sum_{j=1}^{J}\gamma^j y_m^j \geq y_m,\ \ m=1,...,M; \\ &x_n \geq \sum_{j=1}^{J}\gamma^j x_n^j,\ \ n=1,...,N; \qquad (3) \\ &\sum_{j=1}^{J}\gamma^j (I_f^j-\delta_f K_f^j)\geq I_f-\delta_f K_f,\ \ f=1,...,F; \\ &\gamma^j\geq 0,\ j=1,...,J; \\ &x_n\geq 0,\ n=1,...,N; \\ &I_f\geq 0,\ f=1,...,F; \end{aligned}$$

where γ is the $(J\times 1)$ intensity vector. A solution of (3) requires a value for (W_K)[1].

Using the solution of (3) a dynamic cost inefficiency (OE) measure is generated as (see Silva and Oude Lansink, 2012):

$$OE = \frac{w'x + c'K + W_K(.)'(I - \delta K) - rW(y,K,w,c)}{w'g_x - W_K(.)'g_I} \tag{4}$$

The dynamic directional input distance function, measuring dynamic technical inefficiency for each firm is:

$$\begin{aligned}
&\vec{D}(y,K,x,I;g_x,g_I \mid C) = \max_{\beta,\gamma} \beta \\
&\qquad \text{s.t.} \\
&\qquad y_m \le \sum_{j=1}^{J} \gamma^j y_m^j, \;\; m = 1,\ldots,M; \\
&\qquad \sum_{j=1}^{J} \gamma^j x_n^j \le x_n - \beta g_{x_n}, \; n = 1,\ldots,N; \\
&\qquad I_f + \beta g_{I_f} - \delta_f K_f \le \sum_{j=1}^{J} \gamma^j (I_f^j - \delta_f K_f^j), \; f = 1,\ldots,F; \\
&\qquad \gamma^j \ge 0, \; j = 1,\ldots,J.
\end{aligned} \tag{5}$$

The direction vector adopted in this paper is $(g_x, g_I) = (x, \delta K)$, i.e. g_x is the actual quantity of variable inputs and g_I is the depreciated quantity of capital. Further, the dynamic directional input distance function in (5) assumes constant returns to scale. The dynamic directional input distance function under variable returns to scale (i.e., $\vec{D}(y,K,x,I;g_x,g_I \mid V)$) is obtained by adding the constraint $\sum_{j=1}^{J} \gamma^j = 1$ to (5). The difference between $\vec{D}(y,K,x,I;g_x,g_I \mid V)$ and $\vec{D}(y,K,x,I;g_x,g_I \mid C)$ is a measure of scale inefficiency (SE).

Finally, following Silva and Oude Lansink (2012), dynamic overall cost inefficiency is decomposed into the contributions of technical inefficiency under variable returns to scale, scale inefficiency (SE) and a residual term defined as allocative inefficiency (AE):

[1] In this paper, the shadow values of dynamic factors are generated using a quadratic specification of the optimal value function and rewriting it as: $w'x = rW(y,K,w,c) - c'K + W_K{}'(I - \delta K)$. After fitting this specification, the shadow values of quasi-fixed factors are obtained using the parameter estimates.

$$OE = \vec{D}(y, K, x, I; g_x, g_I \mid V) + SE + AE \qquad (6)$$

with $AE \geq 0$.

3. Data

The data used in this study come from the SABI database, managed by Bureau van Dijk, which contains the financial accounts of Spanish companies. The study sample includes the firms belonging to the category of firms in construction of residential and non-residential buildings (NACE Rev. 2 code 4120). This study focuses on the medium-sized firms which are among the most adversely impacted by the crisis as reflected by the significant reduction in the number of firms (Laborda, 2012). Also, focusing on medium-sized firms results in a data set with firms that are comparable in size. The medium-sized firms are those that employ between 50 and 249 employees and that have an annual turnover between 10 and 50 million euros, following the European Union definition.

After filtering out companies with missing information and after removing the outliers[2], the final data set consists of 775 medium-sized firms that operated in Spain in at least one year during the period from 2001 to 2009. Choosing this time span we are able to analyze the years before and after the start of the financial crisis in Spain. The panel is unbalanced and it sums up to 2,460 observations.

One output and three inputs (material costs, labor costs and fixed assets) are distinguished. Output was defined as total sales plus the change in the value of the stock and was deflated using the price index of residential buildings. Material costs and labor costs were directly taken from the SABI database and were deflated using the price indexes of materials of residential buildings and labor costs in construction, respectively. Fixed assets are measured as the beginning value of fixed assets from the balance sheet (i.e. the end value of the previous year) and are deflated using the industrial price index for capital goods. All prices used to deflate output and inputs are obtained from the Spanish Statistical Office (various years). Gross investments in fixed assets in year t are computed as the beginning value of fixed assets in year $t+1$ minus the value of fixed assets in year t plus the value of depreciation in year t. Table 1 provides the descriptive statistics of the data used in this study,

[2] Outliers were determined using ratios of output to input. An observation was defined as an outlier if the ratio of output over any of the three inputs was outside the interval of the median plus and minus two standard deviations.

for the whole period 2001-2009 and for the periods before and after the start of the financial crisis (from 2001 to 2006, and from 2007 to 2009).

Table 1

Descriptive statistics of input-output data, pre- and post-financial crisis.

Statistic / Variable	Mean	Std. dev.	Min	Max
2001-2006 (N=1,548)				
Fixed assets	2.523	4.838	0.020	101.416
Employee cost	2.566	1.188	0.463	7.787
Material cost	12.115	6.512	1.518	43.092
Investments	0.730	1.807	-8.514	36.003
Production	17.886	8.663	3.552	71.386
2007-2009 (N=912)				
Fixed assets	4.793	9.800	0.039	95.977
Employee cost	2.555	1.213	0.716	8.086
Material cost	11.071	6.183	2.406	46.152
Investments	0.806	3.212	-29.048	60.387
Production	16.035	7.822	0.363	54.604
2001-2009 (N=2,460)				
Fixed assets	3.365	7.177	0.020	101.416
Employee cost	2.562	1.197	0.463	8.086
Material cost	11.728	6.411	1.518	46.152
Investments	0.758	2.425	-29.048	60.387
Production	17.200	8.407	0.363	71.386

The data in Table 1 show that in the period after the start of the financial crisis, the value of output and material costs have been shrinking by almost 10% compared to the period before the financial crisis. The cost of employees maintains almost the same, suggesting that firms have less flexibility in adapting the costs of labor, which is likely due to the legal protection of labor. Furthermore, Table 1 indicates that the size of fixed assets is larger in the period after the start of the financial crisis than before. This figure may reflect the change in the composition of the group of medium-sized firms. Firms that were categorized as large firms before the crisis have scaled down and enter the medium-sized firm category after the crisis. However, the financial crisis is reflected in the ratio of investment over fixed assets. This ratio decreased from 29%, on average before the crisis to 17% after the crisis. Also, the volatility, as measured by standard deviation of investments normalized by the mean, is much larger after the crisis than before the crisis, reflecting that firms reacted very differently to the crisis.

4. Results

This section presents the decomposition of overall dynamic inefficiency in the Spanish construction industry for the period pre- and post-financial crisis. Furthermore, dynamic efficiency indicators are compared between firms that differ in size as well as companies that are active versus those that went bankrupt in the time-period analyzed. Differences in overall, technical, scale and allocative inefficiencies between groups of construction firms are tested using the test proposed by Simar and Zelenyuk (2006)[3] denoted as the S-Z test.

Figure 2 presents the Kernel density estimates[4] of overall cost inefficiency for the time-period before and after the beginning of the financial crisis (from 2001 to 2006, and from 2007 to 2009).

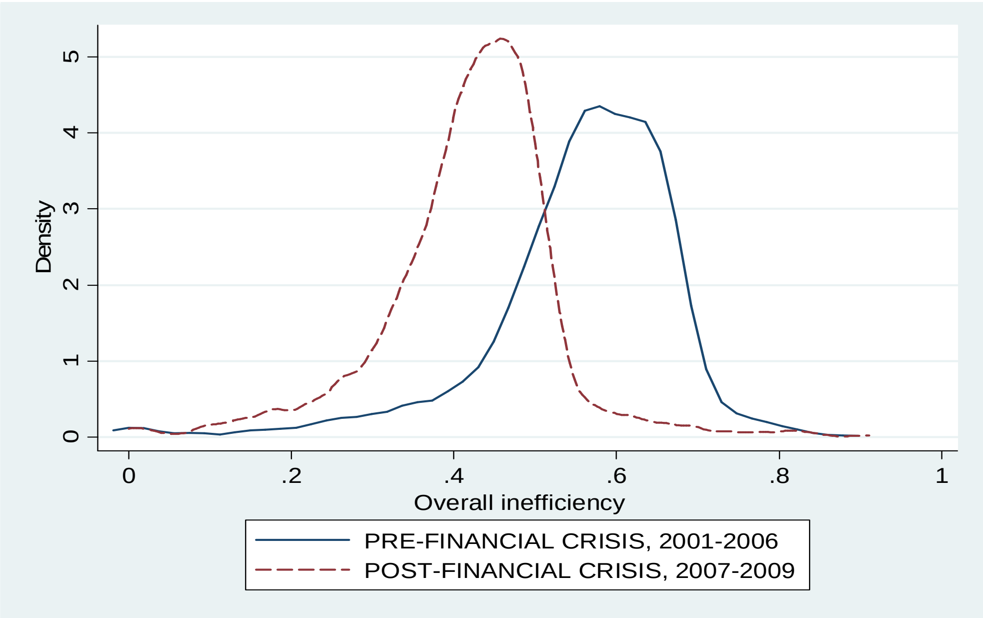

Fig. 2. Kernel density estimates for overall inefficiency, pre- and post-financial crisis.

At a first glance, the graphs in Figure 2 suggest a higher overall cost inefficiency of Spanish construction firms in the period before the financial crisis rather than during the financial

[3] The Simar and Zelenyuk test adapts the nonparametric test of the equality of two densities developed by Li (1996). Simar and Zelenyuk (2006) propose its adaptation to reckon with the specificity of DEA efficiency scores: bounded support of the distribution and the fact that estimated rather than 'true' efficiencies are used. In particular, they propose two algorithms and among them they found the Algorithm 2 to be more robust, hence we apply it here. In essence, the algorithm is based on computation and bootstrapping the Li statistic using DEA estimates, where values equal to unity are smoothed by adding a small noise. The implementation of this algorithm is done in R using 1000 bootstrap replications.

[4] In all subsequent density estimates, we use Gaussian kernel function and Silverman's (1986) rule of thumb to determine the bandwidth.

crisis: the distribution of the period before financial crisis is located to the right of the distribution for the period after the beginning of the financial crisis. The decomposition of overall cost inefficiency in Table 2 provides more insights into the causes of this difference.

Table 2

Evolution of overall, technical, scale and allocative inefficiency, pre- and post-financial crisis (S-Z-statistics and p-values of the differences between two time-periods).

Year	N	Overall inefficiency	Technical inefficiency CRS	Technical inefficiency VRS	Scale inefficiency	Allocative inefficiency
2001-2006	1,548	0.557[a]	0.432[b]	0.335[c]	0.098[d]	0.124[e]
2007-2009	912	0.420[a]	0.321[b]	0.266[c]	0.055[d]	0.010[e]
2001-2009	**2460**	**0.506**[a]	**0.391**[b]	**0.309**[c]	**0.082**[d]	**0.115**[e]
S-Z-statistic		280.458	142.474	41.484	98.261	33.551
p-value		0.000***	0.000***	0.000***	0.000***	0.000***

***statistically significant differences at 1% level

a, b, c, d, e statistically significant differences at 1% level

Using Table 2, one can note that the decrease in overall cost inefficiency of Spanish construction firms in the post financial crisis period is due to a decrease in all its components. Moreover, the inefficiency distributions show significant differences between both periods as indicated by the S-Z test results: the estimated p-values are equal to 0, so the null hypotheses of equality of efficiency distributions are rejected. Three possible interpretations can be derived from this result: 1) some inefficient firms might have been forced to disappear from the market due to, for example, the decrease in demand caused by the crisis; 2) the crisis has worked as a disciplining factor and firms became sharper in allocating resources; and 3) as large firms contract to become medium-sized firms, they bring an additional dimension of experience in construction management to the group of firms in this category. All explanations imply the decrease of firms' inefficiencies in the period of financial crisis. Interestingly, further investigation suggests that the allocative inefficiency decreased dramatically during the years of financial crisis as compared to pre-crisis period. This suggests that Spanish construction firms better succeed in allocating resources so as minimize long-run costs during the financial crisis. Finally, exploring the sources of CRS technical inefficiency decrease in post-crisis period, one can conclude that it occurred mainly due to a decrease in scale inefficiency rather than a decrease in VRS technical inefficiency. Therefore, the main reason behind the improvement in CRS technical efficiency is the fact that the firms' combination of inputs and outputs became less scale inefficient.

Overall for the 2001-2009 time-period, the findings suggest that substantial cost-savings can be realized in the Spanish construction industry; i.e., the combined effect of dynamic technical and allocative factors shows that the average overall cost inefficiency for construction firms is 0.506. Such a high level of inefficiency, on the one hand, is due to the factors under managers' control, and on the other – it might be related to uncertainty in construction delivery which is out of the control of the firm (for example, weather conditions, obstacles in natural conditions of the ground). This relatively high level of overall cost inefficiency is mainly due to technical inefficiency under CRS (0.391) rather than allocative inefficiency (0.115). Average technical inefficiency allows for an improvement of 39.1% in reducing the inputs and increasing investments at a given level of outputs. The average allocative inefficiency of 0.115 suggests that construction firms can reduce costs by 11.5% through a better mix of variable and dynamic factors of production at given prices.

To compare the efficiencies of Spanish construction firms differing in size, two size population classes among medium-sized firms are devised according to the annual sales turnover. The group of small medium sized firms is defined as firms with a turnover that is between 10 and 30 million euros (size class 1), whereas large medium sized firms are defined as firms with a turnover between 30 and 50 million euros (size class 2)[5]. Figure 3 presents the Kernel density estimates of overall inefficiency for these two categories of firms' size for the period from 2001 to 2009.

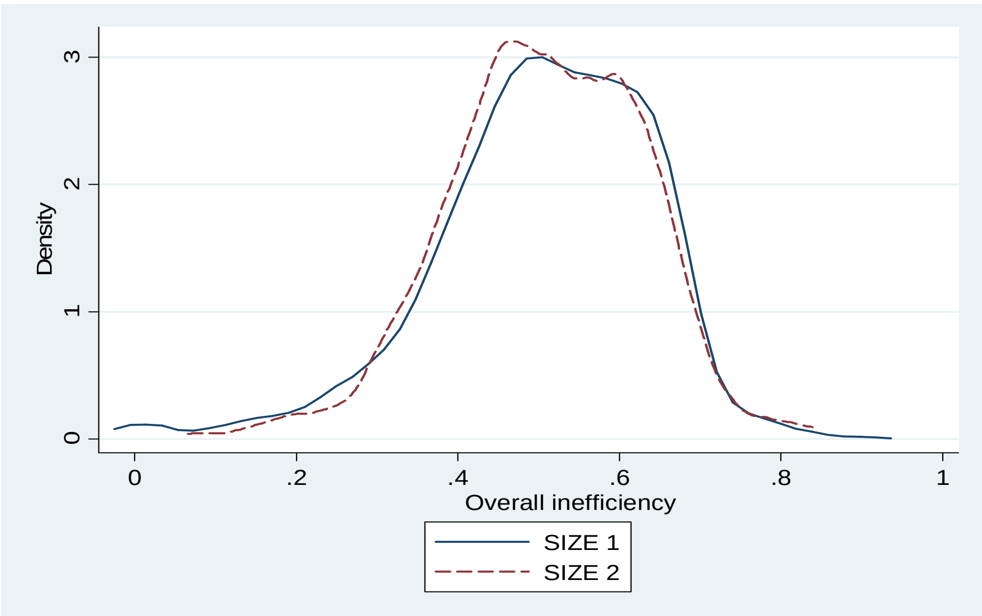

Fig. 3. Kernel density estimates of overall inefficiency for small (1) and large (2) medium sized firms, 2001-2009.

[5] The descriptive statistics of input and output variables for size categories can be obtained from the authors upon request.

It is clear from the graphs on Figure 3 that the distributions of overall inefficiency for small and big medium-sized construction firms are similar suggesting that overall inefficiency may not be associated with firms' size. Table 3 further elaborates this finding by providing the decomposition of overall inefficiency as well as the results of S-Z test of significance of differences in inefficiency between the two size classes.

Table 3

Differences in inefficiency between size classes, pre- and post-financial crisis (S-Z-statistics and p-values of the differences between sizes).

Size	N	Overall inefficiency	Technical inefficiency CRS	Technical inefficiency VRS	Scale inefficiency	Allocative inefficiency
			2001-2006			
1	1,329	0.554	0.441	0.335	0.106	0.112
2	219	0.574	0.376	0.330	0.047	0.197
S-Z-statistic		-0.442	2.754	2.226	48.119	3.106
p-value		0.312	0.000***	0.000***	0.000***	0.000***
			2007-2009			
1	720	0.417	0.328	0.274	0.053	0.090
2	192	0.432	0.296	0.235	0.062	0.136
S-Z-statistic		-1.464	-0.660	5.581	2.358	3.133
p-value		0.635	0.024**	0.000***	0.000***	0.000***
			2001-2009			
1	2,049	0.506	0.401	0.314	0.087	0.104
2	411	0.507	0.339	0.285	0.054	0.169
S-Z-statistic		-1.580	7.168	8.158	27.038	2.836
p-value		0.400	0.000***	0.000***	0.000***	0.000***

***statistically significant differences at 1% level, **statistically significant differences at 5% level

The results in Table 3 clearly provide a support that overall inefficiency of Spanish construction firms is not associated with firm size for both the pre- and post-financial crisis period. The estimated p-values of the S-Z test ranges from 0.312 to 0.635, indicating that the null hypothesis of equality of distributions cannot be rejected. Technical and scale inefficiencies decrease with size: mean inefficiency is lower for larger than for smaller construction firms; however, the difference in magnitude is not large. This result holds in the pre-crisis period and during the financial crisis (from 2007 to 2009 with exception for scale efficiency). Therefore, the results confirm that smaller construction firms are farther away from efficient frontier and are less scale efficient than larger companies. However, the results for allocative inefficiency in Table 3 suggest that larger construction firms have more problems with choosing the mix of inputs and output that minimizes long-run cost than smaller construction firms.

Further insights can be achieved by splitting the sample of efficiency estimates into construction firms that are active versus those that exit the sector due to bankruptcy. Figure 4 visualizes the distributions of overall inefficiency of these two groups of firms during the analyzed period.

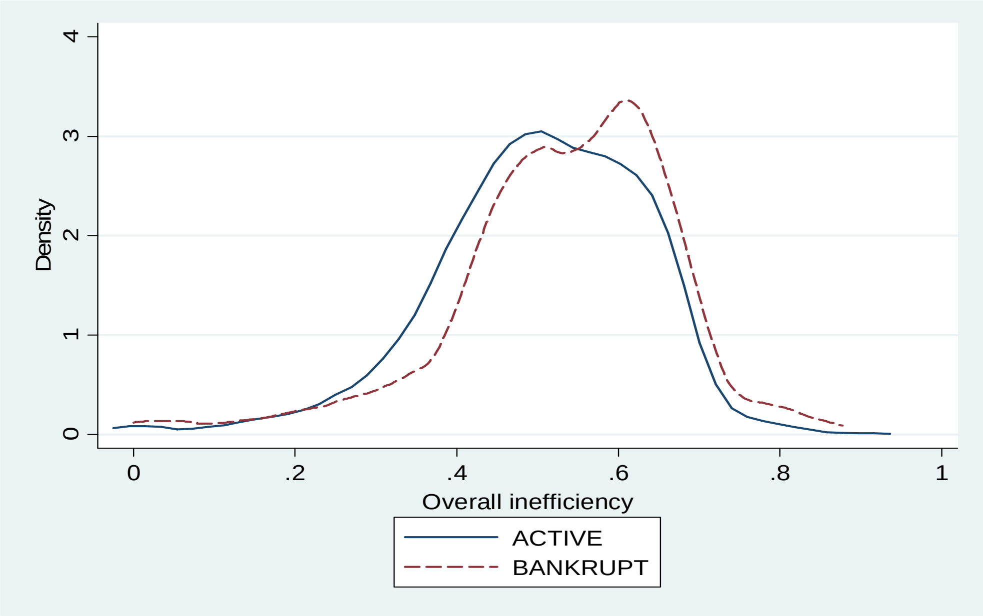

Fig. 4. Kernel density estimates for overall inefficiency, active versus bankrupt firms, 2001-2009.

Figure 4 suggests that overall inefficiency is slightly higher for construction firms that went bankrupt than for active firms. The distribution of overall inefficiency of bankrupt companies is located to the right of the distribution of active companies. However, the differences in distributions of overall inefficiency observed on the graph are not very substantial. Table 4 presents the results of the S-Z test for differences in overall inefficiency and its components for active companies and companies that went bankrupt.

Table 4

Active versus dissolving firms, pre- and post-financial crisis (S-Z-statistics and p-values of the differences).

Activity	N	Overall inefficiency	Technical inefficiency CRS	Technical inefficiency VRS	Scale inefficiency	Allocative inefficiency
			2001-2006			
Active	1,309	0.556	0.433	0.338	0.094	0.124
Bankrupt	239	0.557	0.429	0.313	0.115	0.128
S-Z-statistic		2.798	5.113	2.667	2.667	10.460
p-value		0.168	0.069*	0.214	0.214	0.565
			2007-2009			
Active	834	0.418	0.319	0.264	0.055	0.099
Bankrupt	78	0.448	0.345	0.291	0.054	0.103
S-Z-statistic		3.931	2.333	1.592	4.970	3.018
p-value		0.001***	0.024**	0.217	0.818	0.183
			2001-2009			
Active	2,143	0.502	0.388	0.309	0.079	0.114
Bankrupt	317	0.530	0.408	0.308	0.100	0.122
S-Z-statistic		7.039	6.692	2.449	33.970	12.528
p-value		0.002***	0.002***	0.577	0.004***	0.298

***statistically significant differences at 1% level, **statistically significant differences at 5% level, *statistically significant differences at 10% level

Table 4 shows that overall inefficiency during the 2001-2009 time-period is lower for active construction firms rather than for firms that went bankrupt. In this period, although all inefficiency components are lower for active firms rather than for firms that went bankrupt, only for CRS technical inefficiency and scale inefficiency these differences are statistically significant. Comparing the periods of pre- and post-financial crisis, again in general the lower inefficiencies are observed for active firms, although many differences are not statistically significant. After the beginning of the financial crisis, the differences in overall inefficiency and CRS technical inefficiency between active and bankrupt firms are significantly different, but all other components are not. In the period before the beginning of the financial crisis, the difference in overall inefficiency is not statistically significant, but one of its components, the difference in CRS technical inefficiency is significant.

5. Conclusions

This paper estimates dynamic inefficiency of Spanish construction firms before and after the beginning of the financial crisis and compares the performance of firms of different sizes and for firms that went bankrupt versus those that were not. The empirical application used accountancy data from medium sized construction firms in the period 2001-2009.

The medium sized construction firms in our sample have an almost 10% lower output and material costs in the period after the financial crisis than before. Also, the investment ratio is much lower in the period after the beginning of the financial crisis, while labor cost does not change.

Overall dynamic cost inefficiency is 0.506 in the period under investigation with technical inefficiency (0.309) being the largest component, followed by allocative (0.115) and scale inefficiency (0.082). Overall inefficiency is significantly larger before the beginning of the financial crisis than during the financial crisis; the improvement is mainly due to lower allocative inefficiency. Large medium sized firms are, on average less technically and scale inefficient than small medium sized firms, but have more problems in choosing the mix of inputs that minimizes their long-term costs. In the period after the beginning of the financial crisis, large medium sized firms have a lower technical and allocative inefficiency, whereas small medium sized firms have a lower technical and scale inefficiency. Firms that went bankrupt in the period 2001-2009, on average have a higher overall dynamic cost inefficiency and scale inefficiency than firms that did not go bankrupt.

The implications of our results for the construction firms are that these firms have a substantial scope for improving their technical performance. Better management of their resources can contribute to a reduction of technical inefficiency. Further research is needed though to investigate the factors that are underlying poor technical performance. Also, our results imply that particularly larger firms suffer financial losses due to a poor allocation of resources at given input prices. Big firms and firms pursuing a growth strategy need to pay more attention to this source of inefficiency, e.g. by choosing less costly combinations of inputs.

Our results on scale inefficiency imply that firms need more flexibility in adjusting the size of their operation. Lack of flexibility in adjusting the size due to e.g. legal constraints contributes to the persistence of scale inefficiency. Our data suggest that construction firms have less flexibility in adjusting the size of the labor force. Policy makers can increase labor flexibility by reforming the labor market such that firms can more easily lay off people in times of financial distress.

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