

Recession and Post-Recession Efficiency and Productivity Changes in United States Public Universities: The Good, Bad, and Ugly

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Abstract

This paper employs data envelopment analysis to investigate the extent to which publicly owned, operated, and managed universities in the United States have undergone efficiency and productivity changes in response to the financial crisis that induced the Great Recession and how post-recessionary conditions have altered those changes. The paper revisits an earlier study of like kind that used panel data covering the 2005-2008 academic years but could not, obviously, capture the dynamic changes of the 2007-2009 recession or the lingering post-recessionary financial and enrollment effects imposed on public universities. The present paper offers many improvements over that previous study by extending the panel data to 250 as compared to 133 universities and the academic years to evaluate efficiency and productivity to 2004-2013. Results indicate that university efficiency and productivity gains arose somewhat earlier during the recession than previously estimated but the significant improvements were in lagged response and arising in the 2010 and 2011 academic years. Post-recession results, however, show a bleaker picture with significant efficiency and productivity regress in both the 2012 and 2013 academic years. Without exception, productivity gains can be attributed to technological improvements with university managerial gains being of lesser value. Yet, the recent productivity declines do not bode well for the future implications of U.S. public universities, especially given

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the post-recessionary pressures on all publicly funded institutions to increase productivity.

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1 Introduction

The financial crisis that induced the Great Recession began to transform publicly provided higher education in the United States. Being funded by state governments that subsequently ran large deficits as a result of the crisis, public universities became the subject of budget cutting priorities. Although the recession officially dates from December 2007 to June 2009, state funding financial support for public universities in the U.S. declined from an average of 32% of university operating revenues in the 2008 academic year to 23% by the 2013 academic year [GAO, 2014]. Being an anti-cyclical industry, increases in the unemployment rates created cumulative increases in public higher education enrollments. Enrollments increased 13% from 2007 to 2010 [NCES, 2013]. Economy wide improvements in economic conditions, accompanied by declining unemployment rates, created enrollment decreases in each of the subsequent academic years 2011 through 2013. During the funding cuts and increasing enrollments, university administrations were adjusting employment and capital acquisition decisions, e.g., as cost cutting measures, increasing the number of part faculty relative to full time faculty (NCES, 2014).

The roller coaster ride through these dynamic changes raises questions regarding the impact that such changes impose on the operating efficiencies and productivities of publicly owned, financed, and managed universities. That question was, in part, addressed in an earlier work of this journal by Sav [2012]. Using data envelopment analysis (DEA) and Malmquist indexes, that study found that U.S. public university productivity regressed beginning in 2006 but showed some signs of productivity gain on the order of 1.5% in the 2008 academic year, with the latter potentially being attributed to managerial responses to the imposed effects of the recession. However, that study was based on academic years 2005 to 2008 and, therefore, could not account for the full recessionary or lingering post-recessionary effects on the efficiency and productivity of universities. Thus, with that limited data, additional questions arise as to whether or not that potential efficiency and productivity gain was real and, more importantly, sustainable given the dynamics of funding and enrollment changes that occurred during and following the great recession.

Therein lies the purpose of the present paper. It revisits the previous work of Sav

[2012] but substantially improves upon it with a more comprehensive ability to capture the full impacts of both recessionary and post-recessionary effects on university efficiencies and productivities. With changes in data availability, the present study encompasses 10 academic years, 2004 through 2013, of public university production. That is in contrast to the previous work that was constrained to 4 years, 2005-2008. Adding the earlier 2004 academic year improves the ability to capture, for comparative purposes, the pre-recessionary efficiencies and productivities. The extension to 2013, of course, is, in part, necessary to produce results that include the recessionary effects but also lends itself to need to evaluate and understand the post-recessionary university adjustments and subsequent implications for efficiency and productivity changes. Additional improvements come forth with the ability to include observations on 250 universities as opposed to the previous study's 133 universities; an 88% increase. To make comparisons as constructive as possible, the same DEA and Malmquist methodologies are employed for estimating university efficiency and productivity changes. While using the same output-oriented approach, changes in data availability allow an expansion of university outputs to four in comparison to the three included in the earlier work. The same data availability changes, however, necessitated some modifications to the inclusion of university inputs. Thus, with the extension of years, expansion of observations, and changes in data availability, it cannot, as is usually the case, be expected to produce results that are precisely comparable. Yet, the overall improvements and changes prove to be fruitful in producing results that lead to a richer understanding of changes in university efficiencies and productivities during a period of dynamic changes imposed on U.S. public universities.

The earlier work by Sav [2012] appears to be the first study applying DEA analysis in a panel data framework to U.S. universities. A literature search conducted for the present study suggests that no comparable research has since been forthcoming. Thus, for the present paper, a summary of the pre-2012 work appears unnecessary: an extensive literature review and accompanied references are provided in Sav's [2012] study. Given that, the next section of this paper begins with a recounting of the methodology and is followed by an explanation of the data, results, and concluding remarks.

2 DEA and Malmquist Specification

For consistency, the DEA methodology follows that employed by Sav [2012]. To summarize, the efficiency of multiproduct universities is measured as

$$\sum_{r=1}^s u_r y_{ro} / \sum_{i=1}^m v_i x_{io} \quad (1)$$

where the y_r outputs, $r=1, \dots, s$, and x_i inputs, $i=1, \dots, m$, pertain to a university as denoted by the “o” subscript, while the relative importance of outputs and inputs are defined by u and v , respectively.

The output-oriented envelopment model also mirrors that of Agasisti and Johnes [2009] and can be specified as a constant returns to scale technology, CRS, based on Charnes, Cooper, and Rhodes [1978] as follows:

$$\max_{\phi, \lambda} \phi \quad (2)$$

subject to the respective output constraint of the real and virtual university and the input constraint

$$\sum_{j=1}^N y_{rj} \lambda_j - \phi y_{ro} \geq 0 \quad r = 1, \dots, s \quad (3)$$

$$x_{io} - \sum_{j=1}^N x_{ij} \lambda_j \geq 0 \quad i = 1, \dots, m \quad (4)$$

$$\lambda_j \geq 0 \quad j = 1, \dots, N \quad (5)$$

where the λ are constants and $1/\phi$ becomes the technical efficiency measure for the j th university. Previous work and that to follow in this paper also provides efficiency measures under variable returns to scale, VRS, whereby the $\Gamma=1$ per that of Banker, Charnes, and Cooper [1984]. Thus, under both CRS and VRS, a production frontier of both real and virtual universities determines how efficient or inefficient a university is based on its distance from the frontier. Universities on the frontier are efficient as measured by an efficiency score=1. Increasing distances from the frontier increase inefficiency and generate lower efficiency scores. Hence, efficiency is bounded by $0 \leq \text{Efficiency} \leq 1$. VRS efficiencies are greater than those of CRS due to the scale inefficiencies present in the latter. Thus, scale efficiencies are the ratio of CRS to VRS efficiencies.

With panel data, the Malmquist index (Malmquist, 1953) is employed to measure productivity changes among universities over academic years. Using fairly common notation (e.g., Cooper, et al. [2004]), the index (Fare et al. [1994]) is based on distance (D) functions of productivity in academic year $t+1$ compared to the previous year t as follows:

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})} \right) \left(\frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)} \right) \right]^{\frac{1}{2}} \quad (6)$$

The first term captures the change in efficiency from one academic year to the next and can additionally be decomposed into a pure technical or management efficiency and scale efficiency. The second term accounts for possible shifts in the production frontier by using the academic year $t+1$ technology relative to the previous year, t , technology. Productivity increases generate an index $M > 1$, while deterioration in productivity produces an index $M < 1$.

3 Panel Data

The panel consists of 2,500 observations on 250 U.S. public universities that engage in both undergraduate and graduate education over the 10 academic years 2004 through 2013. The data were drawn from the U.S. National Center for Education Statistics (NCES), Integrated Postsecondary Education Data System (IPEDS). While the panel represents a substantial extension of Sav's [2012] 4 year 2005-2008 study, it did require dealing with cyclical modifications to the variables available in IPEDS via the NCES imposed reporting requirements on universities. In the end, however, it was possible to further improve upon that previous work by extending the university output measures from 3 to 4 and substantially refining the input measures pertaining to university faculty. The resulting university outputs and inputs are summarized in Table 1.

As indicated in Table 1, university outputs include the production of both undergraduate and graduate education as measured by academic year credit hours. Research output is measured by the total of all grants received by the university. Both outputs follow that used by Sav [2012]. To those outputs is added the university's ability to produce student academic success as measured by the percentage of undergraduate degrees completed within 150% of four year normal time to graduation. That success in production as well as the production of the other three outputs depends upon a number of university inputs.

Over the 10 years of IPEDS data, it was possible to extract five consistent measures of university inputs. As indicated in Table 1, there are three labor inputs, including the number of tenured faculty, tenure track faculty, and non-faculty staff employed by universities. It is believed that the separation of faculty by tenure and tenure track and the inclusion of all non-faculty employees offer an improvement over the single total faculty measure and the more restrictive administrative

faculty measure used in the previous study.

Table 1. University Output and Input Summary Statistics

Variable	Median	Mean	StdDev
Outputs			
Undergraduate Education, Credit Hours	2.34E+05	2.94E+05	2.09E+05
Graduate Education, Credit Hours	2.53E+04	4.40E+04	5.19E+04
Degrees Completed, Percentage	45	46	14
Research, Dollars	6.98E+07	1.43E+08	1.90E+08
Inputs			
Tenured Faculty, Number	236	324	294
Tenure Track Faculty, Number	113	135	95
Non-Faculty Staff, Number	790	1448	1795
Capital Equipment, Dollars	3.44E+07	9.47E+07	1.57E+08
Capital Buildings, Dollars	1.40E+08	2.54E+08	3.00E+08
Number of Universities=250			
Total Panel, 10 years=2500			

Moreover, the non-faculty staff input is believed to be an improvement in supplanting the “academic support” variable previously used in Sav [2012] and measured in dollars as a proxy for physical units of labor.

The two capital inputs include the university’s dollar value of equipment and buildings. The former duplicates that previously used while the latter represents an improved capital measure in that it is more inclusive than relying on Sav’s [2012] “auxiliary building capital”. Here, the value of all such capital is represented, including classroom, administrative, research laboratories, student dormitories, as well as, auxiliary buildings such as sports arenas.

Table 1 reveals that although all universities in the sample produce both undergraduate and graduate education and research, they differ in the composition of outputs and inputs. On average, graduate education comprises 13% of total credit hour production but at the median level of production that falls to less than 10%. With increasing pressures on universities to ensure student success, it is interesting that the production of student degree stands at less than 50% at both the mean and median measure of university output. Both the mean and median percentage of tenure track faculty to tenured faculty employed is approximately 30% but with considerable variability as noted by the standard deviations. There is, however, more variability in the employment of non-faculty staff relative to all faculty; that varies from 32% on average to 44% at the median. In part, that may

reflect administrative decisions in substituting the employment of part-time adjuncts and non-tenure track instructors for tenure line faculty. Somewhat of the same variability applies to university capital inputs with buildings comprising more than two and half times that of equipment at the mean but about four times that of equipment at the median.

4 Results

DEA efficiency results are summarized in Table 2 for each of the 10 academic years. Of course, since the official recession spans 18 months, December 2007 to June 2009, and does not coincide with academic year calendars, it is not possible to isolate the recessionary effects on university efficiencies with precision. Being that the 2007 and 2008 academic years encompass the recession, they can, at least in part, serve as a focal point for discussion. However, equal interest lies in the post-recessionary effects of a slow, at best, economic recovery, as well as a return to more normal economic wide conditions.

The mean CRS results of Table 2 show a slight efficiency improvement for universities in 2007 but then followed by a 2008 decline and no change in the following 2009 academic year. With some post recessionary lag, efficiency gains arise in 2010 and again in 2011 but are followed with efficiency deteriorations associated with economic improvements in 2012 and 2013. During the pre-recession 2004-2006 academic years, the average efficiency stands at 0.813 or 81.3%. For 2007 and 2008 years, that average increases to 82.1%, thereby indicating a slight improvement. The average for the five post-recession years falls to 80.7%, being affected, of course, by the poor university performances in 2012 and 2013. However, as the standard deviations indicate, the variability in efficiencies among universities substantially increased in 2011 through 2013 relative to previous academic years. That variability is evident in the widening difference in minimum efficiencies compared to the mean efficiencies, e.g., in 2004 the minimum stood at 60% of the mean and dropped to 49% in 2013.

The absence of the scale inefficiencies embedded in the VRS results produce the larger university efficiencies across all years. However, there are only a few exceptions to the chain of efficiency changes under the VRS compared to the CRS results. Most notably, under VRS model, universities experience an efficiency decrease in the post-recession 2009 year compared to the efficiency stability noted under the CRS estimate. The reverse holds in the 2013 academic year with a slight VRS efficiency improvement compared to the continued CRS 2013 efficiency decrease.

Table 2. DEA Efficiency Results: CRS, VRS, and Scale

Year	Min	Median	Mean	StdDev	%=1
CRS					
2004	0.481	0.807	0.813	0.140	17%
2005	0.454	0.811	0.811	0.141	15%
2006	0.421	0.812	0.817	0.137	18%
2007	0.414	0.816	0.822	0.141	21%
2008	0.397	0.815	0.819	0.143	21%
2009	0.437	0.819	0.819	0.140	18%
2010	0.432	0.836	0.826	0.135	17%
2011	0.458	0.844	0.829	0.142	20%
2012	0.404	0.788	0.793	0.156	20%
2013	0.376	0.756	0.769	0.150	12%
VRS					
2004	0.626	0.964	0.925	0.094	42%
2005	0.578	0.966	0.927	0.090	42%
2006	0.609	0.962	0.926	0.090	40%
2007	0.587	0.972	0.927	0.091	41%
2008	0.614	0.963	0.921	0.096	39%
2009	0.602	0.950	0.918	0.093	39%
2010	0.622	0.949	0.920	0.091	39%
2011	0.621	0.957	0.918	0.093	39%
2012	0.606	0.943	0.903	0.106	39%
2013	0.624	0.941	0.904	0.105	35%
Scale					
2004	0.481	0.895	0.879	0.110	18%
2005	0.454	0.905	0.875	0.119	16%
2006	0.421	0.906	0.882	0.112	20%
2007	0.414	0.908	0.885	0.112	20%
2008	0.397	0.923	0.889	0.113	20%
2009	0.437	0.920	0.891	0.112	20%
2010	0.432	0.933	0.898	0.109	18%
2011	0.496	0.947	0.902	0.112	22%
2012	0.404	0.897	0.877	0.120	20%
2013	0.376	0.854	0.850	0.123	13%

The same increases in efficiency variability hold under the VRS as the CRS results for last of the three academic years.

The percentage of universities that are operating on the frontier and, therefore, are efficient is presented in the last column of Table 2. Again, with the scale inefficiencies included in the CRS results, those percentages are lower than under the VRS results. To capture those differences, as well as the differences in the efficiency estimates under both models, Table 2 also presents the scale results. For the latter, those percentages pertain to universities operating under constant returns to scale. Because the DEA estimates revealed that no universities operated under increasing returns to scale, the Table 2 remaining percentage of universities, therefore, experienced decreasing returns to scale, e.g., in 2013 decreasing returns applies to 87% of universities. Thus, the vast majority of decreasing returns to scale universities are off the frontier and leave the low percentage of universities operating efficiently under the CRS results. But, the largest 21% of universities operating efficiently under CRS occurs during the two recession academic years, thereby being somewhat consistent with an efficiency improvement. Under VRS, there occurs an increase to 41% of efficiently operating universities in the first 2007 recession year, but falls to 39% thereafter and remains stable at that level until the drop to 35% in 2013. The 2012 to 2013 CRS efficiently operating universities falls from 20% to 12% and is the result of the decrease from 20% to 13% in constant returns to scale universities and an increase from 80% to 87% of universities operating under decreasing returns.

Turning to estimates of changes in university productivities afforded by the panel data, Table 3 presents the Malmquist results, including the total factor productivity changes and the decompositions into technological, technical, managerial, and scale efficiency change.

Table 3. Malmquist Productivity Decomposition Result

	Total	Technical	Efficiency	Management	Scale
Mean					
2005	0.995	0.994	1.001	1.005	0.996
2006	0.992	0.982	1.011	1.000	1.011
2007	0.998	0.993	1.008	1.003	1.005
2008	0.996	0.997	1.000	0.993	1.007
2009	0.995	0.992	1.004	1.000	1.004
2010	1.041	1.028	1.013	1.003	1.009
2011	1.025	1.023	1.003	0.998	1.005
2012	0.984	1.024	0.959	0.984	0.973
2013	0.950	0.972	0.976	1.004	0.971
Mean	0.992	0.998	0.993	0.997	0.996
Percent <1.0					
2005	53%	57%	43%	28%	44%

2006	55%	67%	37%	35%	34%
2007	54%	54%	44%	32%	43%
2008	53%	52%	42%	36%	36%
2009	52%	55%	41%	33%	40%
2010	26%	28%	39%	34%	34%
2011	35%	20%	41%	37%	34%
2012	72%	53%	58%	41%	58%
2013	71%	64%	54%	28%	62%
Mean	62%	50%	57%	42%	55%
Percent >1.0					
2005	46%	42%	44%	35%	42%
2006	45%	32%	50%	29%	53%
2007	45%	45%	40%	34%	40%
2008	46%	46%	41%	26%	45%
2009	47%	44%	42%	32%	44%
2010	74%	71%	46%	32%	49%
2011	65%	79%	43%	28%	48%
2012	28%	47%	26%	28%	26%
2013	29%	34%	36%	42%	28%
Mean	36%	47%	33%	29%	34%

The total productivity results indicate that universities managed to improve total productivity in 2007 but then experienced productivity decreases in both the 2008 and 2009 academic years. Taking into consideration a lag in university adjustments to the recession, however, there is a significant productivity gain in 2010 (4.1%) and is followed by yet another gain in 2011 (2.5%). Thereafter, however, the declines in 2012 and 2013 fell even below the pre-recession productivity of 2005. Also, in 2013, the total productivity estimate of 0.992 is but 91% of the largest productivity gain of 1.041 realized in 2010.

In parallel to the productivity changes, the percent of universities operating inefficiently (<1) exceeded just over 50% throughout the 2005-2009 academic years and fell to approximately half that in 2010 (26%). Thus, 74% of universities managed efficiency gains (>1) in 2010. Thereafter, the percentage of universities operating inefficiently took a turn for the worse and rose to more than 70% in 2012 and 2013; by far the highest levels over the 10 academic years. The nearly 30% of universities in 2012 and 2013 that managed to produce total productivity gains were responsible for warding off yet further deterioration in the productivity among all public institutions.

With the decomposition results, it is apparent that largest contribution to total

productivity gains among universities in 2010 and 2011 are due to technological changes resulting in frontier shifts; 2.8% in 2010 and 2.3% in 2011. That is equally evident in the 71% and 79% of universities that were able to create those technological improvements in 2010 and 2011, respectively. That, in comparison to only 45% and 46% of universities with the ability to undertake such improvements during the recession years of 2007 and 2008. The smallest contribution to total productivity improvements in 2010 and 2011 come from managerial efficiency changes with only a 0.3% gain in 2009 and then followed by an efficiency index decline to 0.998 in 2011. However, beginning in 2013 technological improvements among universities began to decline (from 1.024 to 0.972), but was partially offset by improvements in managerial gains from 0.984 in 2012 to 1.004 or 2% in 2013. The scale effects tend to follow university enrollment changes generated by the recession. That is, throughout the two recession academic years and the lingering slow recovery effects of high unemployment, the scale productivity indexes show productivity gains through 2011.

While it is not particularly useful to provide productivity rankings for each year over the panel of 250 universities, Table 4 is intended to shed some insight into overall productivity differences across institutions. Presented are the top ten, median, and bottom ten total productivity ranked universities based on their 2005-2013 mean Malmquist productivity results. There's the good, the bad (or not so bad), and the ugly.

All top ten universities realized total productivity improvements. Those gains vanished with the median five ranked institutions and, obviously, continued to fade for all remaining universities. There is a 30% differential between the total productivity of first and last ranked university. For the top ranked university, all of the total productivity gain is attributed to technological improvement, but efficiency (=1) is achieved across the efficiency, management, and scale measures. The role of technological improvements persists for six of the top ten universities and represents the main driving force in productivity gains. For the remaining four universities in the top ten, efficiency gains are the major contributor. Also, all top ranked universities show productivity gains in both management and scale, absent the ninth ranked university that shows a small scale productivity loss (0.999). For top productivity improving universities, the ten year mean gain is 3.1% and average productivity gains were achieved across on decomposition measures.

Table 4. Rankings By Total Productivity: Top 10, Median, Bottom 10

Rank	Total	Technical	Efficiency	Management	Scale
Top 10 Universities: The Good					
1	1.038	1.038	1	1	1
2	1.038	1.006	1.032	1.015	1.017
3	1.035	1.035	1	1	1
4	1.034	1.026	1.008	1.005	1.003
5	1.029	1.013	1.016	1.012	1.004
6	1.028	1.015	1.013	1	1.013
7	1.028	1.009	1.018	1.005	1.014
8	1.027	1.001	1.026	1.005	1.02
9	1.027	1.025	1.002	1.003	0.999
10	1.027	1.024	1.003	1.003	1
Mean	1.031	1.019	1.012	1.005	1.007
Median Universities: The Bad (or not so Bad)					
123	0.995	1	0.995	1	0.995
124	0.995	1.003	0.992	0.983	1.009
125	0.995	0.991	1.004	0.998	1.006
126	0.995	1.009	0.987	1.002	0.984
127	0.995	0.997	0.998	0.997	1
Mean	0.995	0.996	1.000	0.999	0.995
Bottom 10 Universities: The Ugly					
241	0.951	1.005	0.946	0.98	0.965
242	0.949	0.977	0.971	0.986	0.985
243	0.949	0.977	0.972	1	0.972
244	0.947	0.965	0.981	0.999	0.982
245	0.942	0.951	0.991	1	0.991
246	0.942	0.981	0.96	0.961	1
247	0.939	0.967	0.971	1	0.971
248	0.937	0.937	1	1	1
249	0.878	0.947	0.927	0.958	0.968
250	0.799	0.799	1	1	1
Mean	0.923	0.951	0.972	0.988	0.983

Among the median group of universities, there is productivity regress of 0.5% (0.995) and there is little to no pattern associated with these universities being just

short of possible productivity gains. Three of the five universities, however, do escape productivity declines with respect to the scale measure and two of them actually achieve productivity gains therein. The bottom ranked productivity universities experience the opposite of the top ranked universities in that the productivity regress is driven by productivity losses with respect to technological improvements. In fact, for the 250th ranked university, all of the productivity regress is due to technology.

Beyond that presented in Table 4, the full set of ranking results revealed that 90 of the 250 or 36% of universities achieved a 10 year average productivity gain. Productivity regress fell among 62% of the universities with the remaining 2% avoiding regress but not able to achieve any gains.

5 Summary and Conclusions

The purpose of this paper was to determine the potential effects of the financial crisis and subsequent Great Recession on the operating efficiencies and productivities of U.S. public universities, with an equal eye on establishing, for comparison, the pre-recessionary levels of the same and, additionally, the possible post-recessionary adjustments.

The paper revisits the earlier like work of Sav [2012] in this journal, but offers substantial improvements in the ability to capture those effects over time. While that earlier work produced efficiency and productivity results over the 2005 to 2008 academic years, it could not fully capture the full effects of the recession bounded the official dates of December 2007 to June 2009 nor the possible lingering effects of a slow economic recovery thereafter. This paper eliminated that problem by extending the academic year period of evaluation from 2004 through 2013, thereby offering an improved ability to establish pre-recessionary and evaluate recessionary effects, as well as post-recessionary adjustments in university efficiencies and productivities. In addition, it was possible in the present study to increase the sample of public universities by 88% from the previous study of 133 to the current 250. In an attempt to produce comparable results, the same data envelopment (DEA) methodology was employed.

The DEA results herein, indicate that, based on the CRS and VRS estimates, universities achieved a very slight efficiency gain in the 2007 academic year but the major efficiency gains under the CRS model were delayed to the 2011 academic year and arose earlier under the VRS model in the 2010 academic year. In comparison to Sav [2012], that efficiency gain came somewhat earlier, but, of course, that study was unable to evaluate efficiencies beyond 2008. In extending the analysis to the post-recessionary years, the results herein show a substantial

decline in university efficiency during both the 2012 and 2013 academic years under the CRS estimates, but a slight 2013 efficiency increase under the VRS results. The difference, of course, being due to the scale inefficiencies embedded in the CRS estimates.

The Malmquist results mirror the efficiency changes but are more powerful. The productivity increase in university production arises in 2007 – again, a year earlier than Sav [2012]. In contrast, there occurs a slight productivity decrease in 2008. The present results, however, indicate a lag in university productivity gains possibly resulting from lingering recessionary effects. Those productivity gains are on the order of 4.1% in 2010 and another 2.5% in the 2011 academic year. Post-recessionary 2012 and 2013 academic years paint a bleaker picture with cumulative productivity losses. Those results could not be produced with the limited 2008 data available in the Sav [2012) study.

University productivity rankings with the Malmquist decompositions reveal, unequivocally, that the driving force to productivity gains among universities comes forth with changes in technological improvements achieved over the 10 academic years. University managerial and scale productivity gains are necessary to achieve aggregate gains but play a much lesser role and contributor to the overall gains.

Relative to the findings of Sav [2012], the results herein indicate a shift in university adjustments to the financial crisis and subsequent Great Recession. With the extension of data from 2005-2008 to 2004-2013, university efficiency and productivity gains appear a year earlier but also vanish earlier. However, post-recessionary productivity gains arise and are substantially larger. In part, the differences can easily be attributed to this paper's ability to extend the panel data from 4 to 10 academic years and expand the sample size from 133 to 250 public universities. Combined, that could, therefore, uncover differential changes in university adjustments to external changes brought about by the recession and what followed in terms of university enrollment changes, as well as, changes in state funding support.

Overall, this paper, however, is believed to offer a better understanding of the recessionary and post-recessionary impacts on U.S. public higher education operating efficiencies and productivities. Yet, of concern, is the finding that the post-recessionary period, herein the 2012 and 2013 academic years, indicates rather significant efficiency and productivity declines among publicly managed and financed universities. To what extent those declines carry for future implications, especially given the post-recessionary pressure on all publicly managed institutions to improve operating efficiency, must await more empirical evidence and study.

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