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The Productivity Conundrum: Evidence from the Housing Industry

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The Productivity Conundrum: Evidence from the Housing Industry

Michael S. Puddicombe[1]

ABSTRACT

Productivity is widely recognized as one of the main contributors to increased economic and societal wellbeing. Unfortunately, productivity has been extremely difficult to operationalize in a repeatable context in the construction sector. The result is a lack of consensus on the basic question of whether there has been improvement or decline in the productivity of the sector.This study focuses on productivity in the housing industry. Productivity is especially important in this industry, as in addition to providing shelter, the housing market is the primary source of wealth accumulation in the US. An individual's ability to enter this market will be a function of affordability which will be effected by the productivity of the industry.The combination of academic and societal impacts suggests that there is a need to address a fundamental question: what is the status of productivity in the housing industry. In order to address this question a data base was compiled from the 10-Ks of the largest, long lived, US companies in the single family housing industry. The result is a panel data set that consists of information on 11 firms over a 15-year period. These 11 firms were responsible for approximately 25% of all new home sales in any given year. The data set was analyzed with random effects GLS time series regression. The results indicate that, at best, the housing industry has seen negligible total productivity growth.

KEYWORDS: Housing, Affordability, Productivity

INTRODUCTION

The importance of productivity is widely acknowledged. "Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker." (Krugman, 1994:11) Productivity has been and will continue to be the key to American growth (Bloom and Lerner, 2013).

Fortunately, productivity is defined by a conceptual simplicity that compares output to inputs. Formally: Productivity = Units of Output/Units of Inputs (Chew, 1988). Unfortunately, while this measure can be operationalized with a fair degree of rigor in the manufacturing sector, this has been an extremely difficult concept to operationalize in a repeatable context in the construction industry. The result is a lack of consensus as to how to measure productivity (Crawford and Vogel, 2006) and disagreement as to the basic question of whether there has been improvement or decline in the productivity of the industry (National Research Council, 2009)

Macro-economic studies (Stokes, 1981; Teicholz, 2001, 2004, 2015) have shown a decrease in construction productivity beginning in the mid to late 1960s. In contrast Sveikauskas etal (2018) in a major macro-economic study from the Bureau of Labor Statistics report demonstrated that productivity has increased in various segments of the construction market from 1987-2016. Micro-economic studies employing project and task level data (Haskell, 2004; Goodrun and Haas, 2002 and Grau et al, 2009) have seen increased productivity. While the previous studies focused on the US market, McKinsey & Company (2015) argued that worldwide construction productivity has decreased in the period from 1995-2012. In addition, scholars have

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argued that macro-economic (Rojas and Aramvareekul, 2003) and international (Vogl and Abdel-Wahab, 2015) studies suffer from methodological issues that raise questions as to their conclusions.

This lack of consensus on the status quo presents significant challenges to researchers. Studies focused on identifying mechanisms to improve productivity will be challenged by a conflicting evidence as to the effect of current practices on productivity.

However, this is not to suggest that this is just an academic question. As previously described, productivity is the key to an increased standard of living. Of particular interest, and the focus of this study, is the effect of productivity on the housing industry. It is widely acknowledged that housing is becoming less affordable. According to the 2019 Demographia International Housing Affordability survey the US market is moderately to seriously unaffordable, the UK and Canadian markets are seriously unaffordable and the Australian market is severely unaffordable.

Housing affordability is not a trivial issue. Unaffordability has deleterious effects at both the personal and national levels (Bertaud, 2018). In the US, housing is the primary store of personal wealth (Belsky and Prakken, 2004). An inability to enter the housing market therefore precludes a significant source of wealth accumulation. At the national level unaffordable housing distorts the spatial allocation of labor. The resulting misallocation of resources represents as much as 9.4% of GDP (Demographia, 2019; Hsieh and Moretti, 2015). While productivity is only one of the drivers of housing costs, it is reasonable to suspect that it plays a major role.

The combination of academic and societal impacts suggests that there is a need to address a fundamental question: What is the status of productivity in the construction sector? Specifically, this study examines how productivity in the housing industry has changed over time.

In order to address this question, a data base was compiled from the 10-Ks of the largest, long lived, US companies in the single family housing industry. The period covered by the data base (2003-2017) was driven by the availability of data from the EDGAR (Electronic Data Gathering, Analysis, and Retrieval) system maintained by the SEC. It also encompasses the boom, bust and recovery periods of the real estate market. During this period a significant number of firms ceased operations or merged with other firms. Only firms that were active across the entire time frame were included. The result is a panel data set that consists of information on 11 firms over a 15-year period. These 11 firms were responsible for approximately 25% of all new home sales in any given year. The elimination of firms that ceased operations or merged, combined with the dominant market share of the remaining firms suggests that this data set is biased towards the strongest firms in the industry. Research (Lewrick, Mohler and Weder, 2014) has shown that these types of firms typically demonstrate the greatest productivity.

The focus of the research and the panel nature of the data indicated that random effects GLS time series regression (Cameron and Trivedi, 2010) was the appropriate analytical technique. The results of the analysis indicate that, at best, the housing industry has seen negligible total productivity growth.

The first part of the study examines the literature on productivity in a generic and construction context. Next we detail the construction of the data base that is employed in the study. The results of the analysis are presented and discussed. Finally, suggestions for future research are presented.

LITERATURE REVIEW

Studies of construction productivity have resulted in contradictory findings. According to the National Research Council (2009:17) this situation can be attributed to 3 major factors: "… (1)

variations in the definitions and measures for productivity, (2) the level at which productivity is measured (industry, project, or task), and (3) the diversity of construction projects, their functions, and costs."

Measurement

A fundamental argument in measuring productivity is the use of partial (usually labor) vs total productivity. Craig and Harris (1973) argued that due to the inability to isolate the effect of individual factors partial productivity measures were problematic. They note that manpower productivity (which has been the focus of most construction related research) is particularly suspect. They suggest that factors such as increasing the quality of raw materials could increase labor productivity but would ignore the increased price associated with those materials. The result could be increased productivity accompanied by increased cost. As a result, they argue for a total factor approach which would allow for the recognition of multiple inputs as they effect total productivity. This is not easily accomplished. A major problem associated with this approach is the differences in units associated with the different factors. The result is difficulty with parsing out the appropriate units of inputs for a given level of output and an inability to accurately assess the effect of the different factors.

Miller and Rao (1989) argue that linking productivity to a firm's profitability provides a more inclusive and useful measure. This approach has the advantage of eliminating the differences in units and provides an easily understandable measure for the firm. However, by using revenue instead of units the confounding effects of 'price variation' is introduced. They recognize that profits can be increased either by an actual increase in physical productivity (outputs/inputs) or by the ability to increase price. In that case outputs would go up simply as a function of revenue with no reflection on the cost of inputs. Crawford and Vogl (2006) refer to this as market power where firms can receive a premium for their product, unassociated with product quality. In the housing market these premiums are often associated with imbalances between supply and demand, although they are sometimes driven by speculation as was seen prior to the 2008 bust. The result can be an inflated measure for productivity.

Level

Stokes (1981) relying on Bureau of Economic Analysis and Bureau of Labor Statistics data showed that construction productivity rose at a 2.4% annual rate from 1950-1968 and fell at 2.8% annual rate from 1968-1978. In this study productivity was defined in terms of real (deflated) value added divided by hours worked. The measures of work were taken at an industry level and included all types of projects. Recognizing the implications of these findings he attempted to find structural flaws in the data and the analysis techniques. While there were minor issues, he was unable to reject his findings based on measurement and definitional issues. He then examined a number of constructs that could explain this dramatic change. The results of his analysis is shown in Figure 1.

Table 11.—Factors Contributing to the Change in Productivity in Construction between 1950–68 and 1968–78
(percentage change at annual rates)

Total Change	5.2
Measurement	
Real Output (price indexes)	0.0
Maintenance & Repair	0.0
Current Dollar Pricing	0.4
Composition of Output	0.1
Capital per Worker	
Capital/Labor	0.8
Age of Capital	−0.1
Demographic Changes	0.2
Economies of Scale	0.0
Regional Shifts	0.1
Work Rules	n.a
Residual	3.7

Figure 1 - Stokes, 1981: 502

Allmon etal (2000) conducted an early analysis of productivity that focused on the task level. They employed Mean's cost data for the period 1970-1998. Their measure of productivity focused on labor costs and they included an industry wide sample of activities. While the study did not include a statistical analysis they found that the overall trend was for the cost per unit of output to decrease over this time period. However, they also note that real wages also fell significantly during that time period. They concluded that the fall in real wages and increased use of technology were the main drivers of the decrease in unit cost. In addition, they reported on a work sampling study of 72 projects completed in the Austin, Texas area over a 25-year period. While this analysis again lacked a statistical analysis they found no increase in productivity relative to the direct work hours observed over this period.

Teicholz (2001) in a discussion of the Allmon etal (2000) paper questioned the findings and introduced a graph (Figure 2) which has been widely reproduced. Based on BLS data he argued that productivity based on constant dollars per man-hour for the entire industry has fallen at a .48% compound rate from 1964 -1998. While not discounting their findings he argues that the BLS data demonstrates that the construction industry is at a minimum '… lagging other, almost all other industries in labor productivity." (Teicholz, 2001: 428)

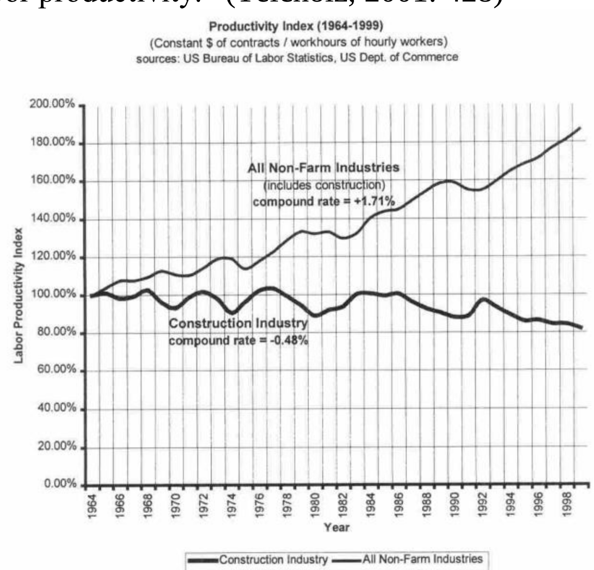

FIG. 15. Graph of Productivity Index for Construction Industry and All Non-Farm Manufacturing Industry (Including Construction Industry) for Years 1964–1999

Figure 2- Teicholz, 2001:427

Following Allmon et al (2000) Goodrum etal (2002) argued that the level of analysis was a major contributor to the appearance of a decline in productivity. When examined at a task level for the time period 1976-1998, they argued that many activities had seen substantial improvement in productivity. The authors selected 200 activities that spanned the range of Construction Specification Institute Masterformat divisions. They measured productivity as the change between the 1976 productivity (A) and 1998 productivity (B) divided by 1976 productivity: Formally (B-A) / A. They examined both labor (hours) and multifactor (labor costs + equipment costs) productivity. Their data sources were industry standard estimating manuals: Means, Richardson and Dodge. They found that in terms of labor productivity 30 activities saw declines, 63 activities were unchanged and 107 activities improved. Multi factor productivity saw declines in 57 activities and improvements in 147 activities. The results varied dramatically but consistently across estimating sources for both hourly and multifactor productivity. Means saw increases of .8% and .7%, Richardson 1.2% and .7%, Dodge 1.8% and 2.9% for hourly and multifactor productivity respectively. Again, the authors acknowledge that real wage declines contributed significantly to the increase in multifactor productivity. Without factoring the declining in real wages multifactor productivity increased at 1.4% rate with a wage adjustment the increase fell to .56%.

Continuing with this research approach Goodrum and Haas (2002, 2004) examined the effect of equipment technology on the improvement in task productivity. This is particularly germane given Stokes (1981) study that suggested that a decrease in the capital/labor ratio, which would be associated with a decrease in equipment technology, was associated with the aggregate productivity declines that he observed. In their study the Capital/Labor ratio when regressed against Productivity Improvement had an adjusted R^2 of .16. These results are in sync with Stokes (1981) results for productivity decline and suggest that "Technological advances explain some of the labor productivity increase from 1976 to 1998" (Goodrum and Haas, 2004: 132)

Rojas and Aramvareekul (2003) examined the macroeconomic studies and argue that there are fundamental flaws with these studies. "The raw data used to calculate construction productivity values and the further manipulation and interpretation of the data present so many problems that the results should be deemed unreliable. The uncertainty generated in the process of computing these values is such that it cannot be determined if labor productivity has actually increased, decreased, or remained constant in the construction industry for the 1979–1998 period." (2003:46). In contrast, Teicholz (2015) updated his 2001 study and showed that construction productivity measured in terms of labor has declined regardless of the deflator employed.

While the academic community may be in disagreement over productivity the practioners community has reached a conclusion. While acknowledging that some productivity gains may have been achieved, they are insufficient. The Construction Users Roundtable (CURT, 2019) sees the "…construction industry as a whole challenged by very limited productivity gains." McKinsey and Company (2017) looking at global construction finds a similar situation with construction lagging far behind other sectors of the economy.

Diversity

Sveikauskas etal (2016, 2018) produced one of the most rigorous studies of construction productivity. It addresses most of the issues that have led to critiques of prior macro-economic research. In keeping with standard BLS nomenclature the entire construction industry is referred to as a sector and individual portions are referred to as industries. The study broke the construction sector down into 4 industries: single family housing, multi-family housing, highways and industrial construction. Each industry was analyzed with a unique price deflator. These deflators are a marked improvement from those previously available and address many of the criticism leveled at macro-economic studies. The study focused only on labor productivity growth due to the difficulty in measuring capital and material inputs. Data was primarily based on the Census of Construction for output and the Census of Construction supplemented by Bureau of Labor Statistics for inputs. Outputs and inputs were defined as follows. "Output is the value of construction work deflated by the appropriate deflator, and also contains non-construction work performed by establishments classified in each industry. Labor input is obtained from Census of Construction data on construction and non-construction workers, supplemented by information on average weekly hours of workers based on the Bureau of Labor Statistics Current Employment Statistics. Labor inputs always include the partners and proprietors in each industry." (2018: 3)

The basic formulation for housing looked at output/labor over time while controlling for the effects of variations in volume. Based upon direct labor (non-subcontract) productivity for the period 1987-2016 was found to increase annually by 1.1% for single family and 3.7% for multifamily housing. The analysis for highway and industrial construction did not control for volume. Again based upon direct labor (non-subcontract) productivity was found to have been flat in highway for the period 2002-2016 and to have increased in industrial construction at a 5.3% rate for the period 2006-2016.

The study then looked to approximate the impact of subcontract labor on productivity. This is critically important as subcontract labor accounts for 44.2% in single family, 74.5% in multifamily, 43.2% in highway and 74.5% in industrial of the total industry labor. The study approximated the labor associated with the defined outputs based upon a series of approximations. While qualitative assessments suggest that the approximations are reasonable, further research needs to be conducted to establish more rigorous measures. Notwithstanding these issues, the previous analysis was repeated using both direct and subcontract labor. The results showed single family productivity increasing to 1.2%, multifamily decreasing to 1.9%, highway decreasing to -2.2%, and industrial increasing to 5.5%.

THE STRUCTURE OF THE STUDY

The formulation for this study recognized the issues put forth by the National Research Council (2009). While it cannot overcome the issues it does explicitly recognize them.

- The measure of productivity in this study is a total factor measure operationalized via the financial records of the firms.
- The level of analysis is the industry, operationalized by summation of the performance of individual firms.
- The diversity of the sector is addressed by focusing solely on the single family housing industry.

The work of Sveikauskas etal (2016, 2018) also informed this study's approach. Their study has significant implications in that it is one of the few if not the only study demonstrating increased productivity at a macroeconomic scale. It also demonstrated a rigorous approach that serves as an exemplar for this and future research. He has been lauded by the industry (ENR, 2019) both for the rigor of his research and its results. While there are significant differences between this and Sveikauskas etal work the basic models are comparable.

In the Sveikauskas etal study the data was drawn from governmental databases and is strictly macroeconomic. The level of analysis in this study is at a macro level but it was explicitly built on micro level data. The information is collected at the firm level but it is analyzed at the industry level. Their research looked at multiple industries within the construction sector this study focuses solely on the homebuilding industry. In their study the focus was on labor productivity, a partial productivity measure, here a financial measure which approaches total productivity is taken. Productivity is also defined in two ways. In the first approach an indexed cost to the firm per unit is developed. This is similar to the Sveikauskas etal measure. The second measure addresses the margins the company achieves (Miller and Rao,1989; Craig and Harris, 1973; Crawford and Vogl, 2006). The unit cost and the margin measures are examined at two levels. The first is associated with the actual construction the second focuses on the overhead (Selling, General and Administrative) associated with the construction.

A challenge with a margins approach is that productivity change can be realized either from actual changes in the relationship between inputs and outputs or from market power improvements (Miller and Rao, 1989; Crawford and Vogl, 2006). Therefore, an additional variable is introduced to allow for an understanding of the effect of market power on the productivity measurement.

In previous studies mixing of different industries has been criticized. In addition, Sveikauskas etal (2016, 2018) showed that productivity varied across industries. In order to avoid this confounding factor, this study focused solely on the single family housing industry. The focus on this industry also allows for a degree of homogeneity in the output that is not available in other studies. Measures of productivity have also varied depending on the study. Macro focused studies have employed unit hours and micro studies have employed both unit hours and some cost units. This study focuses strictly on cost and revenues (Miller and Rao, 1989) and looks at an inclusive cost structure (Craig and Harris, 1973) in developing productivity measures. While these strictures impose limits they should allow for a more rigorous study and generalizability for the industry within the confines imposed.

Data

This study addresses a number of the questions related to the 'quality' of the data used in previous studies. The data was compiled from the 10-Ks of the largest, long lived companies in the single family housing industry. Form 10-K is required by the Securities and Exchange Commission and is a detailed report that accurately reflects a firm's financial activity over the previous year. Form 10-K beginning in 2003 is available on the Electronic Data Gathering, Analysis, and Retrieval (EDGAR) data base. This provided the raw data for the input and output measures. The fact that input and output data was collected from the same source addresses a major issue raised by Rojas and Aramvareekul (2003) and Sveikauskas etal (2016, 2018). Data on housing pricing was obtained from the annual "Demographia International Housing Affordability Survey" (DHI). This survey has been conducted worldwide since 2005 and captures information on housing prices vs median income. This data allowed for the control of market dynamics so that an assessment of the effect of market power on productivity could be made. Lastly housing deflators and industry information was obtained from the US Census Bureau. Overall the three distinct data sources provide an unbiased basis for examining productivity in the single family housing market.

The first step involved the identification of the cohort of firms that would be studied. Builder Magazine has published a list of the top 100 largest homebuilders for a number of years. From this list all the publicly traded firms from 2003 through 2017 were identified. The EDGAR data base has online data beginning in 2003 which dictated the initial year of the study. The Sveikauskas etal (2018) study included 30 years of data vs. the 15 years for this study. However, the time framed examined includes the major boom, bust and recovery cycles in the housing industry so performance in a wide range of conditions is included.

The number of publicly traded firms varied from 20 in 2017 to 27 in 2003. From this cohort 11 firms were identified that had been in the top 100 each year from 2003-2017. In most cases the reasons firms fell out of the top 100 was that they either ceased to conduct business due to failure or merger. In Table 1 the total potential cohort and the selected firms (**bold**) are shown. Their rank and the number of units sold are also included. The selected firms in total averaged approximately 25% of the homes sold in any given year.

2017				2003		
Rank		Volume		Rank		Volume
1	**D.R. Horton**	47,135		1	**D.R. Horton**	37,662
2	**Lennar Corp.**	29,394		2	**Pulte Homes**	32,693
3	**PulteGroup**	21,052		3	**Lennar**	32,180
4	**NVR**	15,961		4	Centex Corp.	29,858
5	CalAtlantic Group	14,602		5	**KB Home**	23,407
6	**KB Home**	10,909		6	**Beazer Homes USA**	15,535
7	Taylor Morrison	8,032		7	The Ryland Group	14,724
8	**Meritage Homes Corp.**	7,709		8	**NVR**	12,050
9	**Toll Brothers**	7,151		9	**Hovnanian Enterprises**	11,531
10	**Hovnanian Enterprises**	6,115		10	**M.D.C. Holdings**	11,211
11	LGI Homes	5,845		11	Standard Pacific Corp.	8,213
12	**M.D.C. Holdings**	5,541		12	Technical Olympic USA	6,135
13	**Beazer Homes USA**	5,525		14	**Meritage Homes Corp.**	5,642
14	**M/I Homes**	5,089		15	**Toll Brothers**	4,911
15	TRI Pointe Group	4,697		16	Weyerhaeuser Real Estate Co.	4,626
16	Century Communities	4,281		19	**M/I Homes**	4,148
19	William Lyon Homes	3,239		22	Morrison Homes	3,667
24	AV Homes	2,491		24	Jim Walter Homes	3,523
41	The New Home Co.	1,310		27	Dominion Homes	3,070
56	Green Brick Partners	990		30	William Lyon Homes	2,804
				37	WCI Communities	2,119
				42	Taylor Woodrow Homes	1,629
				47	Brookfield Homes Corp.	1,528
				49	Orleans Homebuilders	1,424
				59	St. Joe Co.	1,241
				62	Avatar Holdings	1,193
				69	Levitt and Sons	1,029
				78	Capital Pacific Holdings	934

Table 1 Firm Selection

The eleven firms compromise the panel that was analyzed. The EDGAR data base was accessed and the firms' 10-Ks for the 15-year period were employed to determine the operational performance of each firm. For example, in the figure below pertinent information from Lennar Corporation's 2017 10-K is displayed.

(Dollars in thousands)	Years Ended November 30, 2017	2016	2015
Lennar Homebuilding revenues:			
Sales of homes	**$ 11,035,299**	9,558,517	8,335,904
Sales of land	**164,943**	182,820	131,041
Total Lennar Homebuilding revenues	**11,200,242**	9,741,337	8,466,945
Lennar Homebuilding costs and expenses:			
Costs of homes sold	**8,601,346**	7,362,853	6,332,850
Costs of land sold	**135,075**	138,111	100,939
Selling, general and administrative	**1,015,848**	898,917	831,050
Total Lennar Homebuilding costs and expenses	**9,752,269**	8,399,881	7,264,839

Figure 3: Lennar 10-K 2017:27

While these firms engage in a wide variety of activities the Result of Operations section in the 10-K breaks the financial impact down by section allowing for the collection of data that addresses measures of productivity. Costs of homes sold include land and land improvement cost per home. In this example the first measure divides total 'Costs of homes sold' by the number of units sold producing an average Cost per unit:

8,601,346,000/29,394 = 292,623 (cost / unit)

In the second measure Revenue from the 'Sales of homes' is divided by 'Costs of homes sold' producing a measure of the firm's margin.

11,035,299 / 8,601,346 = 1.282974 (margin)

These are unadjusted construction related productivity measures for this firm for this year.

A second productivity measure focuses on SGA (Selling, general, and administrative expense). As can be seen in Figure 3 there are Costs and Sales (revenue) associated with Land, this is land that was not part of Costs and Sales associated with a home. The SGA would be effected by both Home and Land sale. Therefore, it was necessary to back out those costs associated with the Sales of land. Sales of Homes was divided by Total Lennar Homebuilding revenues and multiplied by Selling, general and administrative. This provided an estimate of the SGA associated with the Sales of homes.

11,035,299 / 11,200,242 *1,015,848 = 1,000,887

This cost was then applied as above:

1,000,887,000/ 29394=34,051 (cost / unit)

11,035,299 / 1,000,887 = 11.025 (margin)

These are unadjusted overhead related productivity measures for this firm for this year.

It is important to note the different treatment of land with each measure. In the construction measure the revenue and the cost associated with the built land is included. This resulted from three factors. The first is that the financials did not provide information that would allow for separating the structure from land. The second is that land is an intrinsic part of the home package. You could not have a home without land. In addition, the development of the land is associated with construction costs that should be considered in the measurement of productivity. Ideally the revenue and the cost associated with the raw value of the land would be removed however that would be difficult if not impossible to determine. The SGA is adjusted as it includes costs associated with the sale of land without structures as well as completed structures with land. The assumption is that the percentage of revenue associated with land mirrors the percentage of SGA associated with land. Adjusting total SGA by this factor provides a more accurate representation of the SGA costs associated with homes.

Demographia has been collecting data on housing pricing worldwide since 2004. They have calculated a ratio of median housing price to median income. The higher the value the more that income is being spent on housing. A value of 3 and under has historically been considered affordable. In the study higher DHI values are argued to reflect an ability by the firm to increase the price of the product (market power). While some of the increased price could reflect an increase in the 'quality' of the home it is assumed that the consumer will hold a constant perspective on the value of housing as it relates to income. Figure 4 shows yearly DHI for the United States.

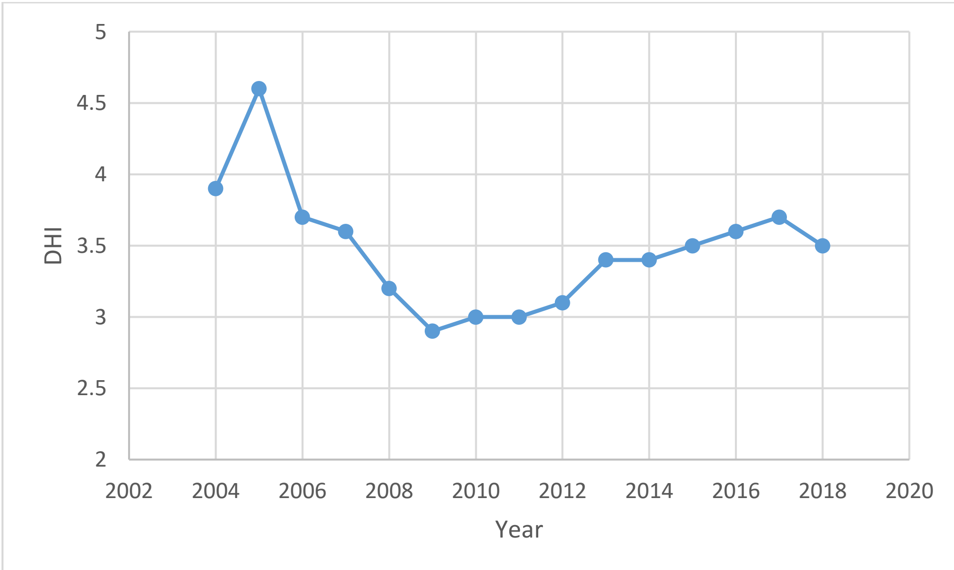

Figure 4: Yearly DHI

Indexes

One of the major issues related to studies of productivity has been the ability to compare projects over time. In the past a number of different indexes developed by the US census bureau as well as private firms (RS Means, Turner) have been employed in developing constant dollar and quality measures for analysis. Recently, the US government has expended a significant amount of effort developing deflators for the construction industry (Sveikauskas, 2016). The Census Bureau has developed measures for the single family housing industry. The Bureau of Economic analysis has developed measures for the multifamily industry. The Federal Highway Administration has developed an index for highways. The Bureau of Labor Statistics has developed an index for industrial construction.

The Census bureau publishes two housing indexes the Laspeyres and the Fisher. In this study the Census Bureau's Laspeyres housing index is employed. The two indexes are highly correlated (>.99) which is understandable given that the Fisher index is a function of the Laspeyeres. The Fisher is assumed to generate a more accurate measure of the effects of inflation (this is the index employed by Sveikauskas) and answers the guestion "What is the (unbiased) value of today's homes being constructed in constant dollars". The Laspeyres answers the question "How much is the sales price today for the same quality house as in the base year?" The base year for all indexes employed in this study is 2005. This index was used to deflate both the revenue and the costs associated with housing construction. The SGA costs were deflated by a composite index constructed from Bureau of Labor Statistics National Compensation Survey and the Producer Price Index. This survey provides deflators for different job categories in different industries. The composite index assumed that the labor made up 90% and material made up 10% of SGA costs. Labor was assumed to be split equally between management, sales and administrative workers. Table 2 shows the values of the two indexes that were employed in this study.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Composite	99.07	100.04	100.00	101.26	100.69	103.46	101.82	102.86	103.05	103.35	104.24	106.02	107.03	107.13	107.77
Laspeyres	85.90	93.10	100.00	106.00	107.00	103.30	98.10	96.40	97.40	98.40	104.80	111.20	114.00	119.80	125.90

Table 2: Indexes

ANALYSIS

The nature of the data (longitudinal panel) and the nature of the question (how has productivity changed over time) dictate that a time series approach be employed. The data allowed variation between firms, over time, and overall to be examined. While all results are presented, the focus of this paper is variation over time (within variation). The results of a Hausman analysis and the fact that all the regressors have non-zero values for within variation indicated that a random effects GLS time series regression be employed (Cameron and Trivedi, 2010). Following Sveikauskas etal (2018) all values were converted to their log equivalents. Specifically, Stata software and the xtreg command was employed.

Unit Cost

The raw data for construction and SGA unit costs is shown in Figures 5-6. The charts show the deflated data point for each firm for each year as well as the average. In Table 3 the results of an analysis of productivity as measured by cost per unit is shown. In this analysis, if productivity were improved, there would be a significant negative coefficient indicating that cost per unit had gone down.

The positive value of the Table 3 coefficients indicates that unit cost has increased and therefore productivity has decreased. The analysis indicates a .2% productivity decrease as measured by construction cost per unit and a .7% productivity decrease as measured by SGA costs per unit. While both equations are significant as is the variable Year, it should be noted that the value of the coefficients and R^2 is small.

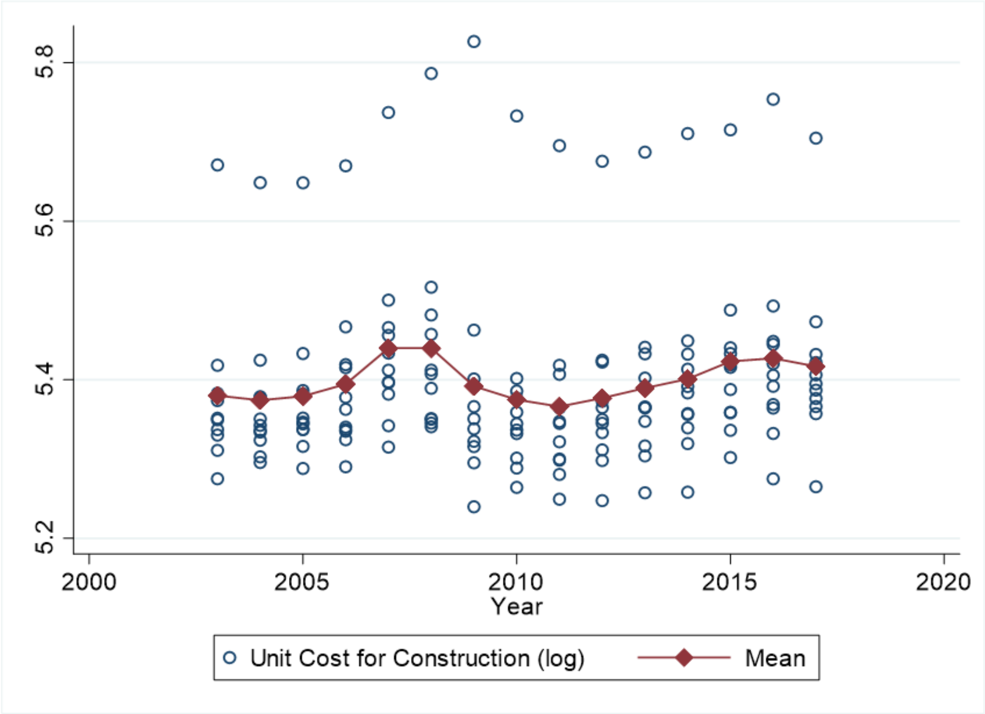

Figure 5

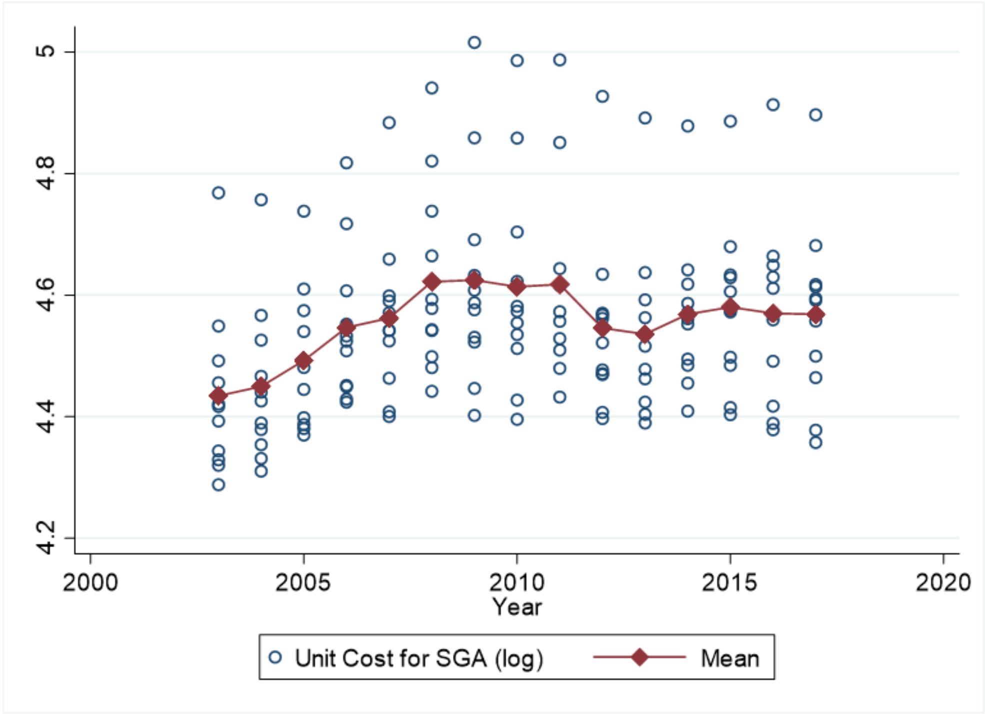

Figure 6

2003-2017	Constant	Year	Sig	R^2	
Construction	1.677	**0.002**	0.013	0.005	overall
cost per unit	2.610	**0.013**		0.000	within
				0.000	between
SGA	**-9.438**	**0.007**	0.000	0.040	overall
cost per unit	**0.000**	**0.000**		0.000	within
				0.000	between

Table 3 Unit Costs

Margins

The raw data for construction and SGA margins is shown in Figures 7-8. The charts show the deflated data point for each firm for each year as well as the average. In Table 4 productivity as measured by margin is shown. In this analysis if productivity were improved there would be a positive coefficient indicating that margins have increased.

The first equation which measures margins related to construction costs is non-significant. The second equation which measures SGA productivity is significant but in the wrong direction. The analysis indicates no trend in productivity as measured by construction margins and a .6% productivity decrease as measured by SGA margins. Again, it should be noted that the value of the significant coefficient and R^2 is small.

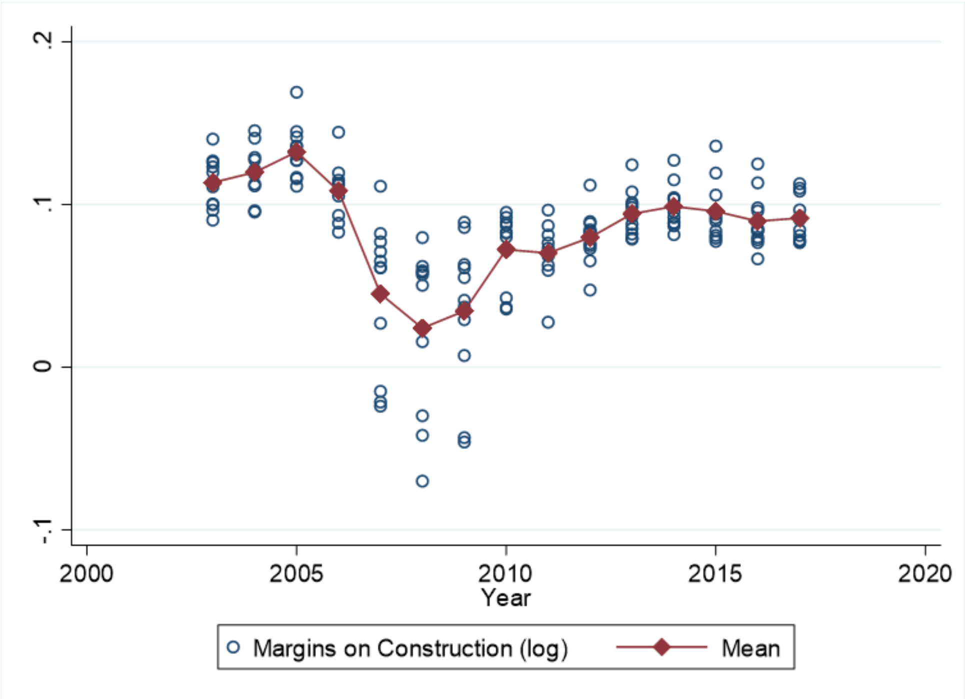

Figure 7

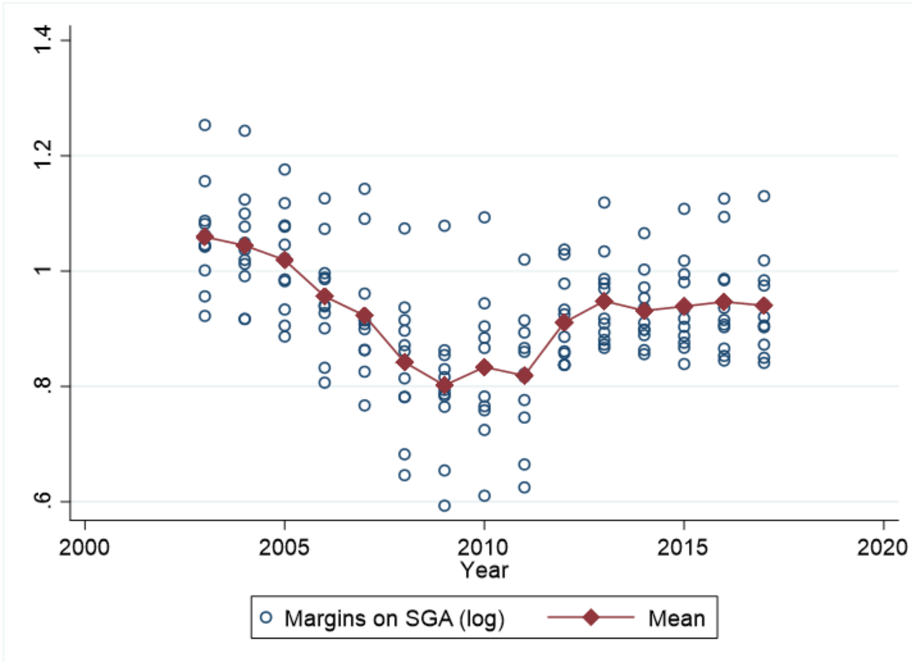

Figure 8

2003-2017	Constant	Year	Sig	R^2	
Construction	1.946	0.001	0.176	0.011	overall
Margin	0.157	0.176		0.000	within
				0.000	between
SGA	13.062	**-0.006**	0.000	0.047	overall
Margin	0.000	**0.000**		0.000	within
				0.000	between

Table 4 Margins

Volume

In Table 5 margin data set was again regressed but a variable measuring company volume was included. As Sveikauskas etal (2018) note the cyclical nature of the construction industry can have a significant impact on productivity. Both equations are significant however this is driven by increases in volume as the Year variable becomes non-significant in both cases. While, the equations show a positive effect from volume, they show no trend over time in construction productivity. Cost per unit was not analyzed as the construct intrinsically accounts for volume.

2003-2017	Constant	Year	Volume	Sig	R^2	
Construction	0.390	0.000	**0.035**	0.003	0.037	overall
Margin	0.784	0.752	**0.002**		0.138	within
					0.001	between
SGA	1.582	-0.001	**0.256**	0.000	0.233	overall
Margin	0.608	0.579	**0.000**		0.368	within
					0.173	between

Table 5 Margins and Volume

Boom, Bust, Recovery

As noted previously the period from 2003-2017 encompassed period of boom, bust and recovery for the housing industry. We therefore conducted the same analysis as above but segmented the data into three periods based upon the number of housing units sold. Boom encompassed the period from 2003-2005 when units sold went from1,086,000 to 1,283,000. Bust is 2006-2011 when units sold went from 1,051,000 to 306,000. Recovery encompassed 2012-2017 when units sold went from 368,000 to 613,000.

In Table 6 the results of this analysis for cost per unit are shown. All equations with the exception of Construction cost per unit for the period 2003-2005 are significant. Of the significant equations the positive values of the coefficients indicate that unit cost has increased and therefore productivity has decreased regardless of the time period. The exception is Construction cost per unit for the bust period 2006-2011 which has a negative coefficient indicating that productivity had improved.

The boom period shows no trend in productivity as measured by cost per unit and a 2.9% decrease in productivity as measured by SGA costs per unit. The bust period shows a 1.1% increase in productivity as measured by construction costs per unit and a 1.5% decrease in productivity as measured by SGA costs per unit. The recovery period shows a .095% decrease in productivity as measured by construction costs per unit and a .06% decrease in productivity as measured by SGA costs per unit. Again, it should be noted that the value of the coefficients and R^2 is small.

2003-2005	**Constant**	**Year**	**Sig**	**R^2**	
Construction	6.135	0.000	0.877	0.000	overall
cost per unit	*0.209*	*0.877*		0.000	within
				0.000	between
SGA	**-53.822**	**0.029**	0.000	0.037	overall
cost per unit	***0.000***	***0.000***		0.000	within
				0.000	between
2006-2011					
Construction	**27.450**	**-0.011**	0.000	0.023	overall
cost per unit	**0.000**	**0.000**		0.000	within
				0.000	between
SGA	**-24.802**	**0.015**	0.005	0.027	overall
cost per unit	***0.017***	***0.005***		0.000	within
				0.000	between
2012-2017					
Construction	**-13.8391**	**0.0095**	0.000	0.022	overall
cost per unit	***0.000***	***0.000***		0.000	within
				0.000	between
SGA	**-8.521**	**0.006**	0.005	0.007	overall
cost per unit	***0.064***	***0.005***		0.000	within
				0.000	between

Table 6: Unit Cost by Time Segment

In Table 7 Margins both with and without volume are examined for the segmented time frames. During the boom period (2003-2005) the equations are significant and Margins associated with construction costs increased while Margins associated with SGA decreased. The analysis indicates a .9% increase in productivity as measured by construction margins and a 2% decrease in productivity change as measured by SGA margins. The introduction of Volume was non-significant and did not change the results. During the bust period (2006-2011) the construction costs equations are non-significant with or without Volume. SGA costs are significant and there is a negative coefficient indicating productivity decreased. The analysis indicates a 2.8% decrease in productivity as measured by SGA margins. When Volume is introduced the Year variable becomes non-significant and increased Volume is associated with increased productivity. During the Recovery period (2012-2017) the Construction and SGA equations are non-significant. When Volume is introduced the equations and Volume variable are significant and increased volume is associated with increased Productivity.

2003-2005	Constant	Year	Sig	R^2		Constant	Year	Volume	Sig	R^2	
Construction	**-18.777**	**0.009**	0.000	0.205	overall	**-20.173**	**0.010**	-0.011	0.000	0.301	overall
Margin	***0.000***	***0.000***		0.000	within	***0.000***	***0.000***	*0.407*		0.747	within
				0.000	between					0.154	between
SGA	**41.180**	**-0.020**	0.000	0.034	overall	**57.487**	**-0.028**	0.126	0.000	0.018	overall
Margin	***0.000***	***0.000***		0.000	within	***0.000***	***0.000***	*0.090*		0.572	within
				0.000	between					0.004	between
2006-2011											
Construction	5.733	-0.003	0.325	0.012	overall	3.690	-0.002	0.009	0.577	0.003	overall
Margin	*0.320*	*0.324*		0.000	within	*0.649*	*0.648*	*0.720*		0.032	within
				0.000	between					0.062	between
SGA	**57.985**	**-0.028**	0.000	0.155	overall	-0.601	0.000	**0.260**	0.000	0.293	overall
Margin	***0.000***	***0.000***		0.000	within	*0.973*	*0.980*	***0.000***		0.494	within
				0.000	between					0.200	between
2012-2017											
Construction	-2.392	0.001	0.089	0.017	overall	-0.626	0.000	**0.022**	0.033	0.252	overall
Margin	*0.101*	*0.089*		0.000	within	*0.716*	*0.717*	***0.045***		0.035	within
				0.000	between					0.370	between
SGA	-7.710	0.004	0.051	0.009	overall	10.117	-0.005	**0.220**	0.000	0.206	overall
Margin	*0.082*	*0.051*		0.000	within	*0.092*	*0.104*	***0.000***		0.210	within
				0.000	between					0.304	between

Table 7 Margins by Time Segment

Market Power

In Table 8 the effect of Market Power is tested. The data used for this analysis does not include 2003 as the DHI data has been collected since 2004. Construction margins and SGA margins mirror the previous analysis that do not include DHI. When DHI is introduced the variable is significant and the R^2 is substantial (.322, .360). When all variables are eliminated except DHI. The results are highly significant and there is a slight decrease in R^2 (.304, .279).

	Constant	Year	Vol C	DHI	Sig	R^2	
Construction	0.464	0.000			0.805	0.000	overall
Margin	*0.764*	*0.805*				0.000	within
						0.000	between
	-1.213	0.001	**0.037**		0.005	0.038	overall
	0.442	*0.463*	***0.001***			0.152	within
						0.000	between
	-2.737	**0.001**	-0.013	**0.486**	0.000	0.322	overall
	0.039	***0.047***	*0.301*	***0.000***		0.373	within
						0.004	between
	-0.142			**0.419**	0.000	0.304	overall
	0.000			***0.000***		0.000	within
						0.000	between
SGA	7.124	-0.003			0.081	0.012	overall
Margin	*0.045*	*0.081*				0.000	within
						0.000	between
	-4.982	0.002	**0.269**		0.000	0.240	overall
	0.118	*0.124*	***0.000***			0.376	within
						0.195	between
	-4.064	0.002	0.072	**1.019**	0.000	0.360	overall
	0.144	*0.130*	*0.072*	**0.000**		0.521	within
						0.195	between
	0.279			**1.189**	0.000	0.279	overall
	0.000			***0.000***		0.000	within
						0.000	between

Table 8 Margins and DHI

DISCUSSION

In Table 9 the results from the analyses are consolidated. Items are color coded for ease of interpretation. Red indicates a decrease in productivity, green indicates an increase, and yellow indicates a non-significant change in productivity.

The first measure of productivity (Cost), Construction (CON) shows a decrease in overall construction productivity. During the Boom period there was non-significant change. There was positive change during the Bust period. There was negative change during the Recovery period. The positive trend during the bust years is reasonable in that firms supplying the homebuilders would be deceasing their prices in order to capture a share of a shrinking market. In terms of SGA cost, productivity decreased regardless of the time frame observed. While this would seem to be strong evidence of a decrease in productivity, the R^2 of the equations indicates that the results should be viewed with caution. The R^2 (< .050) suggest that time is capturing only a small part of the variation in productivity. This is consistent with Figures 5 and 6 which show within (year) and between (firm) variation.

		CON	SGA	CON	SGA	CON	SGA
		YEAR		VOLUME		DHI	
Cost							
Table 3		-0.2%	-0.7%				
Table 6 Boom		ns	-2.9%				
Table 6 Bust		1.1%	-1.5%				
Table 6 Recovery		-1.0%	-0.6%				
Margin							
Table 4, 5,		ns	-0.6%	ns	ns		
Table 7 Boom		0.9%	-2.0%	1.0%	-2.8%		
Table 7 Bust		ns	-2.8%	ns	ns		
Table 7 Recovery		ns	ns	ns	ns		
Price Recovery							
Table 8		ns	ns	ns	ns	0.10%	ns

Table 9 Consolidated Results (Value for Year variable shown)

Productivity as measure by margins does not present as clear a picture. Construction margins show no trend other than an increase in margins during the boom period. SGA margins generally indicate a decrease in productivity. The increase in margins during the Boom would be reasonable given that increased demand would allow homebuilding firms to increase their selling price. However, 63% (10/16) of the margin results are non-significant making any conclusions problematic.

The addition of the price recovery variable, interestingly, was accompanied by a marginal indication of increased construction margin productivity. However, the value .1% and the significance (.047) are both rather low. In addition, the equations that did not include DHI indicated no significance for Year. While the examination of the effect of price recovery is preliminary, the analysis suggests that positive changes in margins are driven by the ability to increase price not reduce cost.

The analysis presented here suggests that there has been no to a negative change in the productivity of the housing sector. This is contrast to the Sveikauskas etal (2016, 2018) studies which have been cited throughout the article. The rigor of that study and its wide distribution requires that the difference in findings be addressed.

There are a number of fundamental differences in the data used to conduct the analyses and they relate to the units employed to produce a productivity measure. In this study the unit of analysis is houses sold. In Sveikauskas it is the value of housing ‘construction put in place’ during the year of interest. In this study the cost function is all costs associated with the production of the sold unit. In Sveikauskas it is labor hours. In addition, this paper was able to segregate SGA while Sveikauskas includes ‘white-collar’ hours. Lastly the sources of the data and timing are different. This paper aggregates yearly data from firms’ 10-K while Sveikauskas (2018) employs Census of Construction data that necessitated interpolation between 5 year periods. The period employed for this study was 15 years while Sveikauskas employed a 30-year period. Taken together these differences would appear to offer an explanation for the conflicting conclusions.

CONCLUSION

Unfortunately, the previous discussion has measurements issues again precluding a definitive statement as to the state of the industry. However, focusing on the differing definitions of productivity may allow a synthesis of these studies. While the goal of this research was to bring clarity to the question of construction productivity, it may indicate a more nuisance dynamic in the housing sector. Combining this research with the results of previous works it would not be unreasonable to state that over the last 30-year period there has been an increase in labor productivity, but not withstanding this improvement, the last 15-year period has experienced decreased total productivity. At best the last 15-year period has shown no change in total productivity. These results beg for additional research. The question of labor versus total factor productivity needs to be investigated in depth. Is the industry substituting material and/or technology for labor and becoming less productive?

Lastly there are the societal impacts. While the analysis is preliminary, it appears that increases in margins are driven by an ability to increase price as opposed to decrease cost. Further research needs to explore this dynamic. While productivity can effect affordability will firms use productivity gains to decrease prices. If firms are able to increase productivity will it result in benefits to the customers as well as the stockholders?

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