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PRODUCTIVITY TREND IN THE OFF-SITE CONSTRUCTION SECTOR OF WOODEN HOUSES

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Abstract

With rising production costs and an insufficient production development, firms in the Swedish industry for wooden single-family houses might face severe problems in productivity. This is gaining in importance, considering that this industry highly tends towards perfect competition, i.e. firms mainly have to compete by prices. This study investigates the productivity of Swedish firms producing wooden single-family houses off-site, by analysing the ratio between turnover and number of employees as factors affecting productivity. 48 firms were studied from 2010 to 2013 and the results show that the average firm productivity in the industry worsened by 6.56 %, with a slight improvement from 2012 to 2013. 23 firms increased and 25 firms decreased their productivity during the investigated time span, yet, from 2012 to 2013, 31 firms improved productivity. Almost half of the 23 firms with increased productivity achieved that betterment even though their turnover decreased and 12 firms improved productivity with declining turnover. Another 12 firms tried to compensate declining turnover with resigning employees, yet, could not keep their former productivity level.

Key words: *wooden single-family houses; productivity; off-site construction; industry analysis; key performance indicator.*

INTRODUCTION

Productivity as a key performance indicator

In general, productivity is a relative performance measure for comparing the amount of output in a certain period of time in relation to the input needed to produce that output (Dyckhoff and Spengler 2010, Lantz 2003). Depending on the purpose of the study to be performed, partial productivity measures can be used to analyse a firms' diverse production factors (Song and AbouRizk 2008, Ohlhager 2013). Common key performance indicators for measuring partial productivity could include e.g. (working) capital productivity or labour productivity (Engwall *et al.* 2014). Yet, studying performance from a more holistic point of view gives insights into a firms' overall system capacity to leverage humans, machines and capital into quantifiable output (Rieper and Witte 2005). Often, total factor productivity is used as a key performance indicator for measuring a firm's productivity (Engwall *et al.* 2014).

Internationally, productivity in the construction industry has been studied with varying results. Whilst e.g. Teichholz (2001) or Durdyev and Mbachu (2011) mention that productivity is relatively low, Eastman and Sacks (2008) found that the growth for off-site productivity is greater than the respective ratio for firms in the on-site construction industry. Abdel-Wahab and Vogel (2011) performed a cross-country comparison including Germany, France, United Kingdom, United States of America and Japan, finding among other things a general slowdown of productivity growth. Shen et al. (2011) concluded that, compared to the US, the productivity of construction firms in China was significantly lower. However, independent of the individual research results, productivity is regarded as a crucial key performance indicator in the construction sector (Alazzaz and Whyte 2014) to evaluate a firm's and an industry's capability to transform and leverage input into output.

The Swedish off-site industry for wooden single-family houses

Firms in the Swedish industry for off-site manufacturing of prefabricated wooden elements, modules or volumes are coping with various challenges. As described by e.g. Schauerte *et al.* (2013), some of these challenges are related to product development and others to market issues, like e.g. a restricted home loan policy (Windborg 2012). Meiling *et al.* (2012) report on management principles for improving firms' effectiveness and efficiency. Johnsson and Meiling (2009) studied the design and

manufacturing process related to product quality, a topic as well investigated by Gustafsson and Eliasson (2013), who e.g. found that the degree of automisation in production can be seen as being related to product quality deficiencies. Further, Eliasson and Sandberg (2015) conclude that firms in the industry do not utilise their cost-competitive production equipment, even though techniques and machines exist.

According to Eliasson (2014), firms in the Swedish industry for wooden single-family houses still have relatively manual production processes and that the difference between those firms and more traditional non-prefabrication firms is rather narrow. This is in line with Brege *et al.* (2004), who state that even though the actual work moves from the construction site towards prefabricating house elements in factory buildings, the work performed is still similar. Thus, off-site production development gets inhibited and potential advantages of off-site prefabrication, as described by e.g. Blismas *et al*. (2006), not fully utilized (Höök and Stehn 2008). Among others, Stendahl (2009) identified an increasing need for more industrialised prefabrication in the industry. The low level of production development hampers efficient ways of working, which in turn would decrease costs and raise a firm's productivity significantly (Eliasson 2011) and increase customer value (Nord 2008). Thus, a growing need for improved productivity in the Swedish construction industry is observed (Larsson *et al.* 2013).

Additionally, production costs per m^2 increased by 72% from 16 691 SEK in 2001 to 28 746 SEK in 2013 (SCB 2015). Yet, compared to a 15% increase of the consumer price index, costs per m^2 should be around 19 200 SEK (Allhorn and Svensson 2014). Thus, as denoted by Jonsson and Rudberg (2014), a relation can be seen between the relatively low productivity in the industry and rising production costs. On the other hand, Schauerte *et al.* (2014) found that this industry is characterized by a high degree of perfect competition (=low concentration rate) with too many active firms, highly substitutional products and prices that are given, i.e. not being influenced by the individual firms (Martin 2011). Thus, revenues and profit margins cannot be raised by higher prices for the products offered, but by cutting costs and working as efficient and productive as possible. It other studies it was found that this kind of competitive relation among firms on the market can lead to a higher productivity (a.o. Funakoshi and Motohashi 2009).

Regarding the development of costs and the above mentioned arguments on production development from studies in the field clearly indicate, that the Swedish off-site industry for prefabricated wooden single-family houses might suffer from a low level of productivity in their operations. However, productivity potentially is affected by external factors. When it comes to the development of sales numbers on the market, the industry had to deal with a decrease from 12 000 delivered wooden single-family houses in 2007 to 4 800 houses in 2012 (Schauerte *et al.* 2014). Firms had to balance this economic downturn against resigning employees, which means to loose competence that would be needed, as soon as the market recovers (Eliasson 2014). Since 2012 the market slowly gained strength and in 2014, 7 000 houses were produced. Lately, the forecast for 2015 has been updated from 8 000 to 9 000 units (TMF 2014, 2015). As productivity is affected by the market development in terms of output and, in this case, the number of employees in terms of input as a production factor, handling that balance is crucial in this highly competitive market and motivates a closer look at these factors for firms in the industry at hand.

OBJECTIVE

The aim of this study is to investigate the productivity of Swedish firms producing wooden single-family houses off-site, and the factors affecting productivity. This is done by studying the market development of these firms in relation to their number of employees. Since these factors are dynamic, a snapshot picture as a current state for one single year without a reference value would be less informative. Therefore a four year period, from 2010 to 2013, was chosen in order to investigate in the firm's productivity trend.

METHOD

As the first step, appropriate firms had to be found as the unit of analysis. Here, the authors used an online information database for the industry of wooden house manufacturers (www.hus.se/trahus), where firms in the industry are listed. The available list was edited according to the criterion *(a) size of the firms*, with a cut-off of 10 employees per firm. Moreover, firms, who did not fulfil the criterion of being *(b) off-site manufacturers*, were removed. The resulting list consisted of 52 firms. In the second step, data on *(i) number of employees* and *(ii) market development* per firm had to be collected. The latter factor had to be further operationalised. Since a firm's market development can be regarded as being reflected by its market share, which in turn commonly is being measured by the firms' turnover (Malhotra 2010), *annual turnover* can be regarded as an appropriate indicator for

market development. At this stage, the authors would like to remind the reader of the investigated firms' composition of turnover. The vast majority of the firms do not only prefabricate and sell wooden single-family houses but are as well turnkey contractors. This means that sold plots of land are included in the total turnover of each firm. Therefore, the collected data does not measure labour productivity or production productivity, but gives an overall picture of the entire firms' ability to transform input into output.

The data collection was performed by means of a statistical online database (www.allabolag.se), where the annual financial statements of all listed firms are publically available. At this stage, one issue needed to be solved. Data on *(i) number of employees* might be misleading, since part time workers not appear as such in annual financial statements. Therefore, the authors followed a recommended procedure by converting part time workers into full time equivalents, using an average number that may vary from year to year (SPRING Singapore 2011). This was considered to be as accurate as possible, bearing in mind that numbers on actual working hours not have been available.

In the statistical online database, 52 firms fulfilled criteria *(a)* and *(b)*, as described above. Of these, four firms had missing data on more than one of the investigated factors for the time period 2010 to 2013 and had to be removed. From the remaining 48 firms, two firms had missing data for year 2010 and one firm for the years 2010 and 2011. Anyhow, these three firms were included in this study, since a year to year change for the remaining years nevertheless could be calculated and analysed.

Since the industry is characterised by a high rivalry amongst firms, research results and conclusions could be used for competitive strategic conduct. However, the authors and their colleagues have tight cooperation with some of the firms in various projects. To avoid dissonance and strife in this professional relation, all firms were anonymised and numbered for the data presentation and analysis below.

For the firms being investigated, data on number of employees and annual turnover was collected and used to calculate firm productivity according to equation (1).

$$FP_t = \frac{T_t}{E_t} \quad (1)$$

where: *FP* is firm productivity, *T* is turnover, *E* is number of employees and *t* is the respective year of interest.

The relative changes in firm productivity from one year to the next year were calculated per firm and for the entire industry. The same was done for the total development of this key performance indicator per firm and for the industry from 2010 to 2013. This, with the above described exceptions of the three firms with partly missing data.

DATA AND ANALYSIS

Appendix 1 shows data for the 48 investigated firms, numbered from 1 to 48. It displays the firms' productivity per year *t* from 2010 to 2013 (FP_t) in Swedish kronor (SEK), changes in firm productivity from 2010 to 2013 ($CFP_{2010\text{-}2013}$), changes in turnover from 2010 to 2013 ($CT_{2010\text{-}2013}$) and changes in number of employees from 2010 to 2013 ($CE_{2010\text{-}2013}$). Further, appendix 1 shows the average firm productivity per year *t* in the industry (average FP_t), the changes in firm productivity from year to year (YoY CFP_t) and the changes in firm productivity from 2010 to 2013 (YoY $CFP_{2010\text{-}2013}$).

The data reveals that the average firm productivity decreases by 4.8% from 3 158 538 SEK in 2010 to 3 006 980 SEK in 2011 and by additional 3.22% to 2 910 174 SEK in 2012. From 2012 to 2013, productivity increases by 1.42% to 2 951 451 SEK. This aggregates to a declining average firm productivity of 6.56% from 2010 to 2013. As mentioned introductory, the market bottomed with 4 800 produced houses in 2012 and gained strengths since then. This seems to be reflected in the data of the industries' productivity; however, no direct deterministic conclusion should be drawn. Productivity is affected not only by turnover but by number of employees as well, compare equation (1). Here, 21 firms show a positive trend in turnover development, whilst 27 firms have declining sales numbers. Further, from the 48 firms investigated, 18 firms have more employees in 2013 compared to 2010, four firms have the same number of employees and 26 firm resigned people during this time period.

Thus, looking at the individual firms' productivity numbers could give insights in how the firms' management anticipated the market development and handled the balance between resigning or hiring employees accordingly.

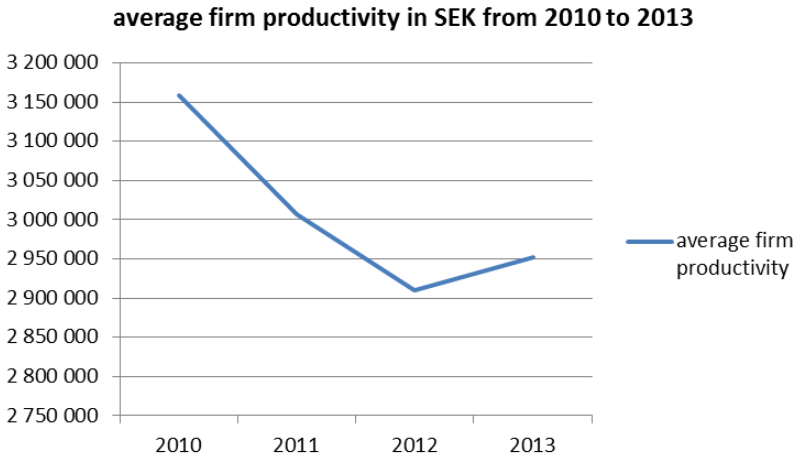

Fig. 1.
Average year to year change in percent and trend line from 2010 to 2013 of Z'-scores of Swedish firms producing wooden single-family houses

Appendix 1 shows that 23 out of 48 firms developed against the negative trend in productivity and had an improvement from 2010 to 2013, whilst 25 firms were down trended. Here, the variance in both positive and negative changes ranges from less than 1 % up to 110 %. As changes in productivity are caused by changes in turnover and/or number of employees, these two key numbers must be investigated to understand the firms' movements in productivity.

Starting with the 23 firms with a positive development in productivity, 12 firms of these had an increasing turnover from 2010 to 2013. Of these 12 firms, three firms resigned employees, seven firms hired employees and two firms did neither recruited nor resigned employees during the investigated time period. The remaining 11 firms with a positive trend in productivity had a decreasing turnover from 2010 to 2013. All these 11 firms resigned employees during this time period.

Continuing with the 25 firms with a negative development of productivity from 2010 to 2013, 16 firms had less turnover in 2013 compared to 2010. Of these 16 firms, two firms recruited employees and two firms had an unchanged number of employees. This is summarised in table 1 below.

Table 1
Summary of number Swedish off-site manufacturers of wooden single family houses with increased and decreased productivity, depending on increased or decreased turnover and change in numbers of employees from 2010 to 2013

	increased turnover (21 firms) and			decreased turnover (27 firms) and		
	increased no. of employees	decreased no. of employees	no change in no. of employees	increased no. of employees	decreased no. of employees	no change in no. of employees
increased productivity (23 firms)	7 firms: no. 4, 8, 13, 30, 31, 39, 44	3 firms: no. 26, 35, 40	2 firms: no. 12, 14	0 firms	11 firms: no. 2, 9, 17, 21, 27, 28, 36, 37, 38, 45, 46	0 firms
decreased productivity (25 firms)	9 firms: no. 6, 11, 15, 22, 23, 35, 41, 43, 47	0 firms	0 firms	2 firms: no. 1, 42	12 firms: no. 3, 5, 7, 10, 16, 18, 20, 24, 25, 32, 33, 48	2 firms: no. 19, 29

Table 1 reveals as well that the majority of the firms' management in the industry anticipated or shortly reacted on market changes and tried to adjust the numbers of employees accordingly. This,

in order to find a balance between market development, i.e. changes in turnover, and number of employees. Yet, this happened with varying success.

In 16 out of 21 firms with an increased turnover, management even recruited employees during the investigated time period. However, in 7 out of these 16 firms, firm productivity increased, whilst in 9 firms, firm productivity decreased.

In addition to that, 23 out of 27 firms with a decreased turnover even had a decreasing number of employees. Yet, only for 11 firms out of these, this led to an increased productivity, whilst productivity decreased for the remaining 12 firms.

Only two firms in the industry recruited employees, even though their turnover decreased. This resulted in a decrease in productivity. Two other firms neither hired nor fired employees, whilst their turnover declined. Even those firms lost in productivity as a consequence.

DISCUSSION AND CONCLUSION

The aim of this study was to investigate in the productivity of Swedish firms producing wooden single-family houses off-site, and the factors affecting productivity. This was done by studying the market development, i.e. changes in turnover, of 48 firms in the industry in relation to their number of employees for the time period 2010 to 2013.

As mentioned earlier, the Swedish industry for prefabricated wooden single-family houses is characterised by a high degree of perfect competition (Schauerte *et al.* 2014), which requires efficient ways of working, i.e. a high firm productivity. The need for an improved productivity was identified as well by Larsson *et al.* (2013). The results of this study show that the average firm productivity for the entire industry worsened by 6.56% from 2010 to 2013; yet, a slightly improvement could be found from 2012 to 2013 (+1.42%).

Looking at the individual firm level, 23 firms increased and 25 firms decreased their productivity from 2010 to 2013. Variations in productivity changes vary from less than 1% to 110.9%. Yet, from 2012 to 2013, 31 firms (65%) could increase their productivity.

Almost half of the firms that improved productivity from 2010 to 2013, i.e. 11 firms (48%), did so even though their turnover decreased. This might indicate that the respective firm's management found a good balance between market development and keeping or resigning employees. A similar argumentation could be true for the other 12 firms (52%) that improved productivity and did so with a rising turnover. Seven out of these recruited people, three resigned people and two firms had no changes in number of employees. Nevertheless, all these firms handled it in a way that increased their productivity.

Among the 25 firms with a downgraded productivity, 12 firms (48%) tried to compensate their declining sales numbers with resigning people; yet, they did not succeed to do that with keeping their former productivity level. Nine firms (36%) of those with worsened productivity face improved market development conditions and recruited employees to accommodate demand. It would be presumptuous to derive that those firms' management failed. A positive market development for the coming years was forecasted and proactive strategic conduct in the firms' staffing policy potentially could be the ground for future success. As the market recovers and gains strengths, employee competence is needed and can be regarded as a competitive advantage.

The development of the investigated firms and the Swedish industry for prefabricated wooden single-family houses should be object to further research in various ways. To start with, industry specific key success factors could be identified in order for firms to better handle market fluctuations and keep a steady level of productivity and profit margins. A partial productivity indicator for technical efficiency should be developed to follow the firms' production development towards a higher degree of automisation or industrialisation. This was regarded as a crucial factor even in earlier studies, among others Eliasson (2014) and Schauerte *et al.* (2014). Combined with that, product development initiatives towards multi-family house applications should be studied, since the housing shortage in Sweden enlarges year by year (Schauerte *et al.* 2014) and a more industrialised approach in producing prefabricated wooden elements, volumes or modules could be mastered by several of the firms investigated in this study.

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Appendix 1

Firm productivity in Swedish kronor, changes in turnover and number of employees for Swedish off-site manufacturers of wooden single family houses from 2010 to 2013

firm no.	FP_{2010}	FP_{2011}	FP_{2012}	FP_{2013}	$CFP_{2010-2013}$	$CT_{2010-2013}$	$CE_{2010-2013}$
1	3 468 484	3 419 485	2 586 261	2 592 059	-25,3%	-5,2%	26,9%
2	3 556 547	3 739 833	5 203 800	4 308 611	21,1%	-58,9%	-66,0%
3	1 215 886	300 953	1 101 920	845 613	-30,5%	-38,4%	-11,4%
4	1 707 102	1 623 857	1 792 717	1 970 538	15,4%	22,5%	6,1%
5	1 914 133	1 866 172	1 890 828	1 898 643	-0,8%	-7,4%	-6,7%
6	NA	3 704 278	4 841 564	3 550 706	-4,1%	81,1%	88,9%
7	1 535 522	1 833 286	1 309 955	1 409 190	-8,2%	-16,2%	-8,7%
8	2 386 395	2 888 872	2 344 769	2 626 698	10,1%	53,5%	39,5%
9	3 515 180	3 473 741	3 144 324	3 911 667	11,3%	-3,8%	-13,5%
10	5 895 175	5 971 226	5 843 532	5 702 484	-3,3%	-4,8%	-1,6%
11	10 438 642	3 610 722	3 839 978	3 310 065	-68,3%	1,7%	220,8%
12	3 624 800	3 691 364	3 145 200	3 757 700	3,7%	3,7%	0,0%
13	NA	NA	1 291 863	2 724 461	110,9%	119,6%	4,1%
14	6 939 400	7 731 000	6 461 000	7 799 800	12,4%	12,4%	0,0%
15	3 909 222	3 877 222	3 583 400	3 321 455	-15,0%	3,8%	22,2%
16	1 005 583	877 750	986 500	804 800	-20,0%	-33,3%	-16,7%
17	3 063 167	3 229 692	3 543 273	3 220 800	5,1%	-12,4%	-16,7%
18	5 796 382	4 113 559	2 921 730	3 187 983	-45,0%	-51,5%	-11,8%
19	1 956 947	1 698 824	1 537 056	1 574 316	-19,6%	-19,6%	0,0%
20	1 000 985	1 905 768	1 580 425	310 964	-68,9%	-89,3%	-65,6%
21	3 506 686	5 198 953	4 535 303	3 538 394	0,9%	-3,7%	-4,5%
22	3 293 600	1 937 091	1 627 148	2 145 310	-34,9%	25,9%	93,3%
23	3 351 667	2 066 250	2 593 600	2 873 700	-14,3%	185,8%	233,3%
24	1 981 125	1 862 440	1 679 556	1 787 167	-9,8%	-32,3%	-25,0%
25	NA	1 805 826	1 689 000	1 567 136	-13,2%	-33,4%	-23,3%
26	1 987 971	2 232 441	2 146 939	2 654 273	33,5%	29,6%	-2,9%
27	968 625	1 734 167	1 062 917	1 839 400	89,9%	-40,7%	-68,8%
28	2 806 830	2 748 302	2 861 465	2 983 293	6,3%	-17,8%	-22,6%
29	7 339 400	7 870 400	6 639 000	6 605 800	-10,0%	-10,0%	0,0%
30	3 336 697	4 106 059	3 278 077	3 610 626	8,2%	11,8%	3,4%
31	764 091	1 166 385	1 060 846	1 384 786	81,2%	130,7%	27,3%
32	2 472 000	1 900 833	1 976 286	2 447 435	-1,0%	-55,4%	-54,9%
33	3 453 250	3 211 821	3 117 875	3 162 500	-8,4%	-35,9%	-30,0%
34	3 362 108	3 069 365	2 789 907	3 179 825	-5,4%	2,2%	8,1%
35	1 954 500	3 820 250	3 680 600	3 068 800	57,0%	30,8%	-16,7%
36	2 189 028	2 182 996	2 134 678	2 756 037	25,9%	-3,3%	-23,2%
37	2 831 294	2 628 600	2 746 769	2 925 643	3,3%	-14,9%	-17,6%
38	5 878 600	5 314 610	10 562 208	8 274 233	40,8%	-13,5%	-38,6%
39	1 764 907	1 942 990	1 771 364	2 137 357	21,1%	39,8%	15,5%
40	2 137 400	2 264 400	1 870 000	3 119 250	45,9%	16,7%	-20,0%
41	1 759 500	2 935 571	1 851 625	1 538 333	-12,6%	12,4%	28,6%
42	1 599 400	1 369 400	1 661 324	1 052 613	-34,2%	-18,4%	24,0%
43	6 135 667	3 712 600	3 453 765	3 505 214	-42,9%	33,3%	133,3%
44	3 486 579	4 212 458	4 095 680	4 028 107	15,5%	70,3%	47,4%
45	2 636 053	2 929 661	2 756 802	3 110 231	18,0%	-5,0%	-19,5%
46	1 547 371	1 571 563	1 775 655	1 664 192	7,5%	-20,1%	-25,7%
47	1 348 952	1 245 419	952 475	1 073 674	-20,4%	63,0%	104,8%
48	5 311 375	4 729 602	4 367 382	4 807 785	-9,5%	-31,7%	-24,5%
average FP_t	3 158 538	3 006 980	2 910 174	2 951 451			
YoY CFP_t		-4,80%	-3,22%	1,42%			
YoY $CFP_{2010-2013}$				-6,56%			