SWEDEN VERSUS EUROPE IN CONSTRUCTION SECTOR PRODUCTIVITY - A TFP APPROACH

Jan-Eric Nilsson, Johan Nyström, Johan Salomonsson, VTI

The purpose of this paper is to use accounting data for eight European countries to establish whether lagging productivity of Sweden's construction industry is an anomaly or if it is a pattern in the construction industry in many countries. The KLEMS data base is used to compare total factor, capital and labour productivity for both the construction industry and the economy as an aggregate for the 1996 to 2014 period for eight countries. Within this sample, the construction industry performs worse than their within-country peers represented by three ways to measure productivity within each of the countries. Moreover, the analysis does not provide indications of differences between the situation in large and small EU countries.

Keywords: Total Factor Productivity, Construction Industry, Country Comparison.

INTRODUCTION

This paper was triggered by governmental reports indicating that productivity in Sweden´s construction industry is lower than in other sectors of the economy; see for instance SOU 2012:39 and SOU 2015:105. Similar concerns over the industry's performance have been raised in for instance the US and UK, resulting in several studies of these countries, sometimes also including Japan and Germany. An extensive literature addresses the substantial difficulties to measure productivity in the construction industry, challenges that may be less severe in other sectors of the economy. This gives reason to question productivity measures that indicate a dismal performance. But even though there are challenges with measuring construction industry productivity, these complications should be generic and affect all countries in a similar way. While several papers address construction sector productivity in larger countries, less empirical work is reported about smaller countries. It is not obvious that productivity patterns in large and small countries coincide. Moreover, there may be geographical differences between a (small) central European country like Austria, or a small eastern European country like Czech Republic. Against this background, the purpose of this paper is to analyse whether the patterns of productivity in small countries' construction industry differ from that in larger EU countries. Consistent information across countries at the firm or even single contract level would provide the ideal platform for productivity analyses and comparisons. Since no data of this nature is available to an extent that makes a broader country comparison possible, this paper uses aggregated data on sector-level for European countries, collected by the EU KLEMS project. The European Commission funded this research in order to make comprehensive and harmonised national accounting data available on industry level. The data is open source and available at EU KLEMS official webpage, euklems.net. The paper begins with a short literature review. Following a brief introduction to the methodology, data are described, and an overview is given of characteristics of each country´s factor input statistics in the construction industry. Productivity estimates based on KLEMS data for the construction industry relative to other parts of the economy are presented for eight European countries. The last section concludes.

PREVIOUS STUDIES OF CONSTRUCTION PRODUCTIVITY

Lacklustre productivity in the construction sector has been a topic in the literature for decades (eg; Allen 1985; Teicholz, et al. 2001; Fulford & Standing 2014). Another observation is that the construction industry seems to be lagging behind other sectors with respect to the use of Information and Communication Technology (subsequently referred to as ICT; cf. Bankvall et al. 2010; Fulford & Standing 2014). In a review of the literature Naoum (2016) identifies some recurrent explanations of the industry's poor performance. This includes less investment in technology and innovation than in other sectors, recurrent errors in project design, poor experiences of project managers, inappropriate planning and procurement design as well as communication style of leadership. Except for output heterogeneity, Rødseth et al. (2019) discuss two additional risks for bias in productivity studies in a Norwegian context. One is that it is more difficult to include quality improvements in the design of price deflators than in other sectors; a better way to account for quality improvements over time would at least make performance less paltry. Another explanation is that the definition of the construction industry' fails to include complementary industries in the analysis, which then may miss important productivity improvements.

There are many approaches to study productivity, but they all have seek to estimate the relationship between one or more inputs in the production of an output. The most common measure is labour productivity, defined as value added growth over hours worked. One result in the literature is that the construction industry's growth of average labour productivity in Germany and France is lower than in the US (Ive et al. 2004, & Mason et al. 2008). This study focuses Total Factor Productivity (TFP) which is the increase in output that cannot be explained by increasing inputs (Zhi et al., 2003). From a neo-classical perspective, TFP stems from technological progress. In empirical work, TFP may also be explained by scale economies, technical efficiency, mark-ups and organizational improvements (Ruddock & Ruddock 2011). Ive et al. (2004) and O'Mahony & de Boer (2002) cannot establish a difference in UK labour productivity compared with Germany and France while TFP is relatively higher in UK than in the other countries. Ruddock & Ruddock (2011) evaluate trends in the construction industry for UK from the 1971 to 2007 using KLEMS data. One result is that TFP growth is higher in UK than in Germany during the period 2000-2007 while US is about the same. Another finding is that UK´s value added growth per worker is higher than Germany, US, Japan and the aggregated EU15.

Results from using aggregate data for international comparisons are ambiguous and sometimes contradictory. To overcome at least some challenges of this nature, Abdel-Wahab and Vogl (2011) compares the productivity development in the industry as an aggregate relative to construction between 1971-2005 in Europe, US and Japan. They show that the productivity growth was lower in the construction sector than in the total economy and suggest one reason to be lower technological development in construction. Making country comparisons of productivity is per se a challenge. Abdel-Wahab and Vogl (2014) points out that cross-country productivity analysis relies on data where definitions and coverage may differ between countries. Further, they stress that cross-national comparisons are sensitive to the methods used to harmonize output to a common and comparable currency. Moreover, the heterogenous nature of construction projects makes aggregated studies less robust than comparisons of the manufacturing industry. One reason is that there are substantial differences between what is delivered by construction projects (i.e. bridges, roads, shopping malls, accommodations, etc.), which makes it more difficult to compare performance relative to manufacturing which is reasonably homogenous in different parts of the country as well as between countries. There are also substantial differences between building houses or bridges on the one hand and the repair and maintenance of physical assets on the other. Hence, the aggregation of data causes a loss of valuable variation about projects and may mean that likes are not compared with likes.

CONCEPT & METHODOLOGY

Following Jorgenson et al. (1987), eq. (1) defines TFP assuming constant returns of scale, technical efficiency and competitive markets.

$$TFP = \frac{Y}{f(L,K)} \qquad (1)$$

Further assumptions include that production functions are equal and full capital and labour utilization. The Cobb-Douglas production function in eq. (2) can be used to clarify how changes in output in country i at time t ($Y_{i,t}$) is described by changes in the volume of input and by the residual TFP; output as well as input volumes are expressed as log-transformation and first difference.

$$\Delta \ln(Y_{i,t}) = \bar{v}_{i,t}^{K} \Delta ln(K_{i,t}) + \bar{v}_{i,t}^{L} \Delta ln(L_{i,t}) + TFP_{i,t} \qquad (2)$$

Eq. (3) defines the weights of input factor for labour and capital, respectively, and $\bar{v}_{i,t}^{K}$ and $\bar{v}_{i,t}^{L}$ in eq. (2) is the average of these factors over two periods.

$$v_{i,t}^{K} = \frac{P_{i,t}^{K} K_{i,t}}{P_{i,t}^{Y} Y_{i,t}} \text{ and } v_{i,t}^{L} = \frac{P_{i,t}^{L} L_{i,t}}{P_{i,t}^{Y} Y_{i,t}} \qquad (3)$$

Further, capital input can be decomposed into ICT and non-ICT capital where $\delta_{i,t}^{ICT}$ and $\delta_{i,t}^{N}$ is the share of total capital input that stems from ICT and non-ICT, respectively:

$$\Delta ln(K_{i,t}) = \delta_{i,t}^{ICT} \Delta ln(K_{i,t}^{ICT}) + \delta_{i,t}^{N} \Delta ln(K_{i,t}^{N}) \qquad (4)$$

Labour input can be decomposed into hours worked, $H_{i,t}$, and labour composition $LC_{i,t}$. The second term in equation (5) is the sum of wage shares $w_{l,it}$ for labour type l in country i at time t, and $\frac{H_{l,it}}{H_{it}}$ is the share of worked hours by labour type l plus an expression for worked hours.

$$\Delta ln(L_{i,t}) = \sum w_{l,it} \Delta \ln \frac{H_{l,it}}{H_{it}} + \Delta ln(H_{i,t}) = \Delta ln(LC_{i,t}) + \Delta ln(H_{i,t}) \qquad (5)$$

Inserting equation (4) and (5) into (2) gives (6), which decomposes contributions to output volume growth into five components; ICT-Capital, non-ICT capital, labour composition, worked hours and TFP where all variables are in first difference log-transformation form.

$$\Delta \ln(Y_{i,t}) = \underbrace{\bar{v}_{i,t}^{K} \delta_{i,t}^{ICT} \Delta ln(K_{i,t}^{ICT})}_{ICT-Capita} + \underbrace{\bar{v}_{i,t}^{K} \delta_{i,t}^{N} \Delta ln(K_{i,t}^{N})}_{non-ICT-Capital} + \underbrace{\bar{v}_{i,t}^{L} \Delta ln(LC_{i,t})}_{Labour\ composition} + \underbrace{\bar{v}_{i,t}^{L} \Delta ln(H_{i,t})}_{Worked\ hours} + \underbrace{\Delta \ln(TFP_{i,t})}_{TFP} \qquad (6)$$

DATA SOURCES

An inherent challenge for all cross-country comparisons is the appropriate handling of bias related to price level and exchange rate changes over time. Following Abdel-Wahab and Vogl (2011), our strategy is to use the rest of the economy in each country as a benchmark for comparison with the construction industry. This provides control for country-specific conditions that hold for other parts of the domestic economy than only construction. This design is, by construction, sensitive to sector-specific shock to the reference sectors, meaning that if the productivity goes down (up) in the reference-sector, construction´s productivity will appear as increasing (decreasing).[1] One way to reduce this risk is to use three different sectors as benchmark. Total industries refer to basically all industries, the Market economy is the same as Total industries minus real estate activities, public administration and defence, compulsory social security, education, health and social work. Furthermore, compositional changes, i.e. changes in share of road constructions, residential construction and so on, are assumed to affect all countries in a similar way in the long run. To capture changes in the composition of the labour force, KLEMS make use of both employment data and labour force surveys. This makes it feasible to consider the possible consequences of the changes in the composition of the labour force. Information is thus available about gender, age (as a proxy for experience) and educational achievements[2], which break down the labour force into $(2 \times 3 \times 3)$ 18 employee categories.

PRODUCTIVITY

The comprehensive picture

Table 1 corresponds to eq. 7 and show estimates for changes in value added and input contribution for all 15 countries in the material.

Table 1 Annual growth of value added and input changes in the construction industry

[1] Data for the construction industry is defined as category F, i.e. an aggregation of division 41-43 in the NACE rev.2 classification. For relative TFP measures are following aggregations used; Total industries, Market economy and Manufacturing. Total industries is basically all industries except from category T and U, where T is: "Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use" and U is "Activities of extra-territorial organisations and bodies" Amt, S. (2008). Market economy is Total industries but excluding L, O, P and Q (L: Real estate activities, O: Public administration and defence, compulsory social security, P: Education, Q: Health and social work. Amt, S. (2008)). Manufacturing industry is an aggregation of division 10-33 (for a more details see Amt, S. (2008) or Jäger (2016))

[2] Gender: male or female. Age groups (in years): 15-29, 30-49 and >50. Educational level: University graduates, Intermediate, no formal qualification.

		Contributions						
	Growth rate of value added	Hours Worked	Labour composition	ICT	Non-ICT	TFP	start	end
AT	-0.4	0.1	0	0.1	0.3	-0.8	1996	2014
BE	2.5	0.4	0.2	0.2	1.4	0.4	2000	2014
CZ	-1.5	-1.1	0.7	0.1	1.3	-2.6	1996	2014
DE	-1.6	-1.7	0.2	0.1	0	-0.2	1996	2014
DK	0.8	0.3	0.7	0.1	0.2	-0.5	1996	2014
FI	0.3	1.3	-0.1	0	0.3	-1.2	1994	2014
FR	-0.2	0.5	0.2	0	0.2	-1	1994	2014
IT	-0.9	0	0.1	0	0.3	-1.2	1996	2014
LU	1.1	0.2	1	0.2	0.8	-1.1	2009	2014
LV	-7.8	-6.4	0.6	0	-1	-0.9	2009	2014
NL	-1.1	-1.2	0.7	-0.1	0	-0.4	2001	2014
SE	1	0.8	-0.4	0	1.2	-0.7	1994	2014
SI	-12.5	-5.4	1.1	-0.1	-1.6	-6.4	2009	2013
SK	4.3	1.1	-0.3	0	1.7	1.8	2005	2014
US	-1.8	-0.6	0.2	0	0.3	-1.8	2001	2014

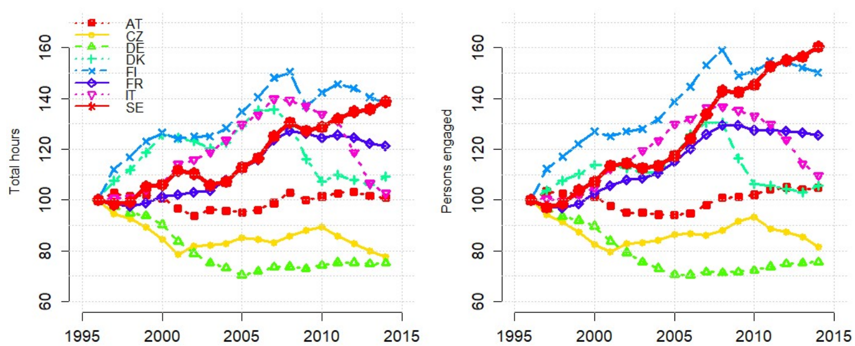
Numbers might not add up due to rounding.

It is, however, obvious that the information covers different time periods. The rest of the analysis will therefore consider eight countries for which data is available for the same time period, i.e. 1996-2014.

Labour input

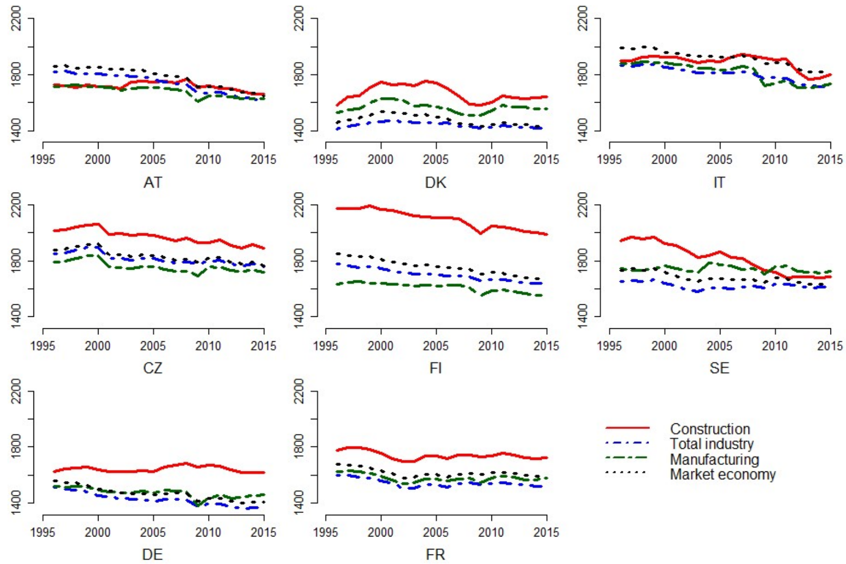
Figure 1 indicates that the input of construction labour has increased in Finland, Sweden and France while the input of labour is substantially lower in 2015 than in 1996 in Germany and the Czech Republic. All eight countries experience at least some reduction in the labour force as a result of the 2008 financial crises, but the reduction of the labour force seems to be structural in the latter two countries.

Figure 1 Total working hours and number of persons engaged in construction (1996=100)



Total number of hours can be decomposed into number of workers and number of hours worked by each. Figure 2 show how hours per worker has developed since 1996 in construction and in the three industries that are used as benchmarks. A first observation is that workers in the construction industry toil more hours per worker than in the other sectors in five of the eight countries. Secondly, most countries have reduced the annual working hours per person for all sectors over this time period. This is most notable in Sweden where working hours in construction has shrunk from almost 2000 hours (1997) to less than 1700 hours per worker from 2010 and onwards.

Figure 2 Annual hours per worker in construction relative to three benchmarks.



It is possible to demonstrate that construction have a larger share of labour input than many other industries. One reason is that output is heterogenous and varies from project to project, making it more complicated to standardize and automize production. Moreover, the manufacturing industry has been able to move labour intensive parts of the production to countries where labour is less costly. This is not feasible for the construction industry since the ultimate task is geographically locked to where the building or road will be placed. The construction industry is also known to hire low-wage labour from other countries to cut costs. However, countries with strong unions and restrictive labour market policies can protect their members and their working conditions.

Capital input

The use of capital is measured as capital services and reported in ten categories[3] which are aggregated using weights based on rental prices, depreciation, capital gains and nominal rate of return; for details see O'Mahony and Timmer (2009). The construction industry's capital stock primarily comprises heavy equipment and Figure 3 demonstrates that three non-ICT categories dominate; Other Machinery and Equipment[4], Transport Equipment[5] and Total Non-residential investment[6]. Other Capital is minor capital posts aggregated. For most countries, Non-residential Investments are the dominating capital category followed by Other Machinery and Equipment.

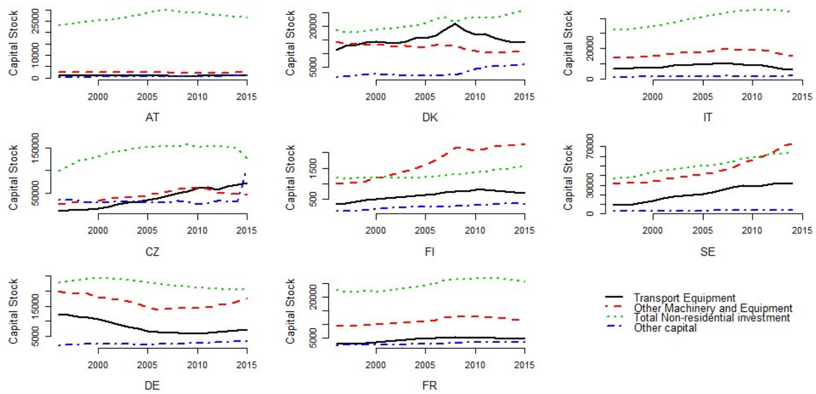
Figure 3 Real fixed capital stock with 2010 prices

[3] Computing equipment, Communications equipment, Computer software and databases, Transport Equipment, Other Machinery and Equipment, Total Non-residential investment, Residential structures, Cultivated assets, Research and development, Other IPP assets.

[4] "The other machinery and equipment category of non- financial, produced, tangible fixed assets consists of machinery and equipment assets not classified as "transport equipment" - stats.oecd.org

[5] "Transport equipment (assets) consists of equipment for moving people and objects, other than any such equipment acquired by households for final consumption" - stats.oecd.org

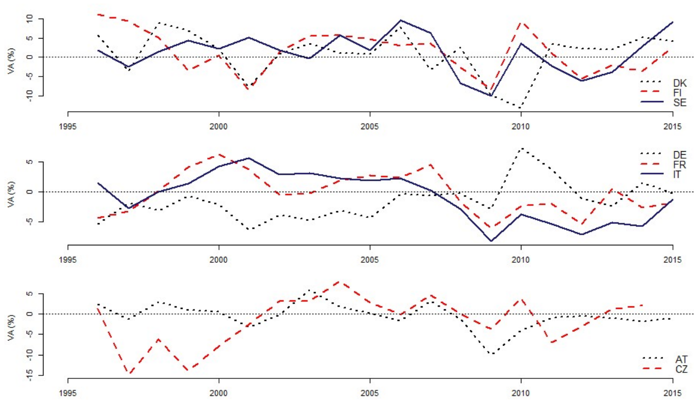
[6] Capital such as commercial real estate, tools, machinery, and factories.



Value added growth

Value added (VA) is the production value net of inputs[7]. Where P is prices, Q is quantities, and subscript y is output and input is input factors as labour and capital. Figure 4 show value added volume growth from 1996 to 2015. Trivially, negative VA statistics indicate that the industry is a burden on the economy at large.

Figure 4 VA quantity growth (%)



From 1997 until the financial crisis, VA growth is generally positive. But there is a difference in how the countries recover. Austria, Denmark, Finland, Italy and Sweden are all having a large drop in VA growth 2009, one year after the Financial Crisis, with numbers between -8.2 to -10 percent. While most countries seem to have higher growth 2010, Denmark is falling further to 13.1 percent. During five years after the financial crisis, neither Austria nor Italy have positive VA growth. Growth in France is positive one out of five years, while Finland and Sweden have positive growth two of five years. Denmark recovers fastest with only negative growth 2009 and 2010 before growth turns positive.

TOTAL FACTOR PRODUCTIVITY

Figure 5 confirms that TFP in manufacturing has the strongest development. Productivity development in the Market economy and in the Total economy is similar,

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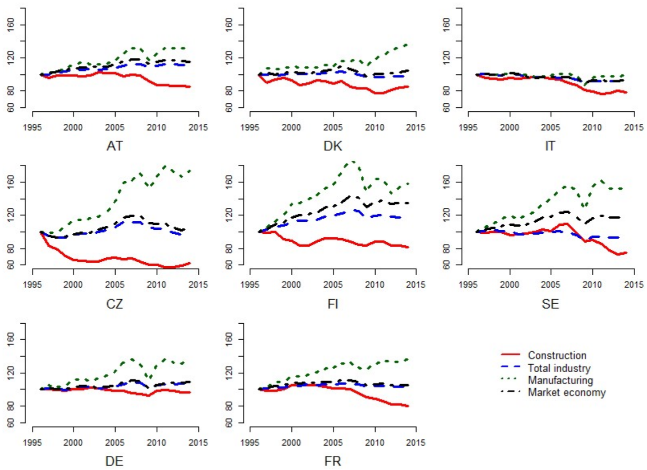
[7] $$\mathrm{VA} = \mathrm{P_{VA}} \times \mathrm{Q_{VA}} = (\mathrm{P_y} \times \mathrm{Q_y}) - (\mathrm{P_{input}} \times \mathrm{Q_{input}}), \quad (7)$$

where P is prices, Q is quantities, and subscript y is output and input is input factors as labour and capital.

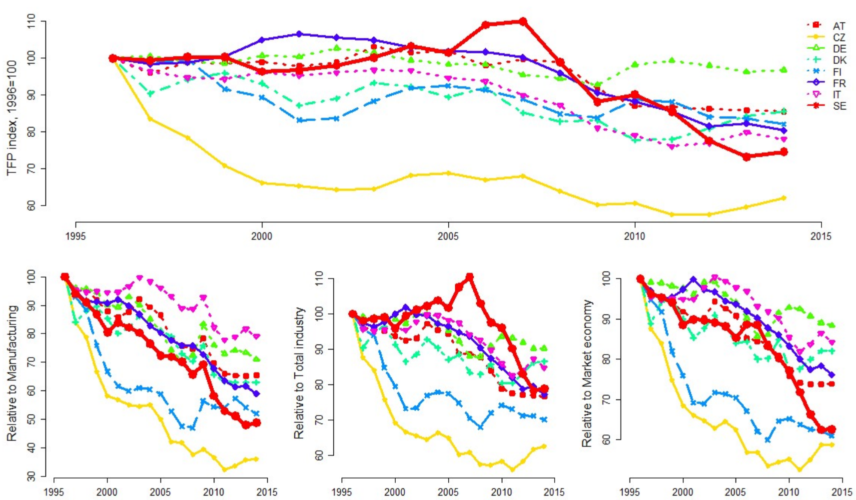
although the first, which excludes non-competitive submarkets, is slightly stronger. The pattern for the construction industry is that TFP is lower than in the other industries and indeed consistently negative.

Figure 5 TFP growth (1996=100)



The upper panel in Figure 6 show TFP estimates for construction. Excluding the Czech Republic, TFP was approximately constant until 2007 while it falls into negative numbers during and after the financial crisis.

Figure 6 Relative TFP measures



Lower panels in Figure 6 relates TFP in construction to manufacturing, total industry and the market economy. The overall pattern is the same irrespective of which measure is used: Not only is construction´s TFP falling in absolute numbers (first panel), it is also shrinking relative to the three alternative ways to measure the economy in total. It is not straightforward to interpret negative technological efficiency, which literarily means that firms are using less efficient production methods over time. There are, however, many empirical studies that have shown negative results (e.g. Ruddock & Ruddock 2011; Abdel-Wahab & Vogl 2011; among others). One common explanation relates to problems with capturing quality improvements over time. On a tangible level, buildings and roads built today may last longer than those produced ten years ago, and this may not be captured by the data.

Further, if the functional form of the production function is less accurate or if omitted variable bias is larger in construction. Another possible explanation is that shares of different types of constructions in the aggregate data are changing over time. One example could be that if the share of road construction goes up and house construction goes down, and one of them are more productive than the other, this will affect the registered change of productivity. Vogl and Abdel-Wahab (2015) provide a similar explanation in that the share of construction and repair and maintenance.

CONCLUSIONS

The relevance of this paper stems from a general perception that productivity performance is poor in the construction industry. The international debate has encouraged researchers to study productivity in construction, but most papers focus large countries, e.g. US, UK, Germany and Japan. Our paper tries to generalise results by comparing construction with other sectors within each country and then compare relative TFP growth across countries. Moreover, the analysis includes both larger and smaller countries. The paper established that the development of TFP in construction is similar across the size of the economies and geographical location. TFP is on average negative for 12 of 15 countries, which is a challenge to interpret theoretically but is a common finding in empirical studies. When productivity in construction is compared to the same statistic for other sectors of the economy for eight countries with a consistent time series, the result is that TFP performs less well. Sweden is perhaps the country where the relative TFP is most sensible and crucial to what part of the economy the industry first is compared to (see lower panels in Figure 6). The homogenous TFP patterns indicate that there is a similar underlying structure valid for the construction as such, i.e. TFP is not as country dependent as believed beforehand. The credibility of productivity measures in the construction industry are widely debated due to the heterogenous nature of output, problems with accounting for quality. However, it is neither possible to control for quality of output or proportion of tasks within construction, with aggregated sector data. Instead, the standard assumption is that proportions of tasks changes with the same probability in all countries and will affect all countries in similar ways in the long run. Descriptive KLEMS information establishes that working hours and non-ICT capital are the main inputs in most country´s construction industries. This is not surprising since construction is a labour and machinery driven industry in contrast to the manufacturing industry which, at least until now, has had higher potential in automatize production and move labour intensive parts elsewhere. However, the descriptive statistics reveals that there are variations in capital and labour characteristics. Interestingly, Denmark had a significant increase of "other capital" (which in their case consisted of increasing investments in ICT-capital) during the financial crises. Another observation is that hours per worker has decreased in Sweden from 1950 to less than 1700 hours between 1996-2011. Decreasing hours per worker isn't as clear pattern in other countries. The heterogenous nature of construction work might suggest that it has been more difficult to use new technology in the same way as repetitive tasks in for example the manufacturing industry. Another way to look at it, is that the construction industry might have a huge, not yet adopted, potential in new technology. This emphasizes the significance of further strengthen the understanding of TFP performance in the construction industry, not least as a means for an improved future development.

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