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Production hierarchies in Sweden☆

Joacim Tåg*

Research Institute of Industrial Economics (IFN), Box 55665, 102 15 Stockholm, Sweden

HIGHLIGHTS

- Swedish occupation data can be used to construct hierarchies within firms.
- The resulting hierarchies conform to theoretical predictions.
- Firms with more layers are larger in size, in value added, and pay higher wages.
- Firms are hierarchical: higher layers are smaller and have higher mean wages.
- Adding layers correlate with firm size/value added increases and wage decreases.

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ABSTRACT

I study the internal organization of firms using Swedish occupation data. The empirical patterns match the theoretical predictions of Caliendo and Rossi-Hansberg (2012) and are similar to the patterns observed in French data by Caliendo et al. (2012).

1. Introduction

Caliendo et al. (2012)—henceforth CMRH—describe a method through which data on worker occupations can be used to construct hierarchies within firms. They use data on French production firms to provide support for central theoretical predictions from Caliendo and Rossi-Hansberg (2012)—henceforth CRH.

CRH builds on the idea in Garicano (2000) and Garicano and Rossi-Hansberg (2006) that firms are hierarchies of knowledge. Production inputs are labor and knowledge. Workers solve problems that arrive, and problems they cannot solve they pass up to managers. Managers use workers because they are time constrained and workers allow them to focus on the problems only they can solve. Managers pass problems to other managers when they cannot solve them. This generates hierarchies, with less knowledgeable workers further down in the hierarchy. When firms grow, they need to hire more workers and/or add more layers of management because growth means more problems need to be solved. When firms expand by adding a layer, pre-existing layers need less knowledgeable workers. As workers are paid according to their level of knowledge, mean firm-layer wages at pre-existing layers should fall when layers are added and rise when layers are removed.

The contribution of this paper is to show that Swedish occupation data can be used to construct hierarchies as in CMRH, and that the resulting hierarchies support the theoretical predictions in CRH that are as follows.

1. Firms with more layers are larger in size, in value added, and have higher mean wages.

* Tel.: +46 8 665 4524; fax: +46 8 665 4599.
E-mail address: joacim.tag@ifn.se.

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2. Firms are hierarchical: lower layers have more workers and lower mean wages than higher layers.
3. Adding layers is associated with increases in mean firm size/value added and decreases in mean firm wages at pre-existing layers. The reverse holds for removing layers. This result also holds for layer-by-layer mean layer size and mean layer wages for a majority of pre-existing layers.

Support for prediction three is noisier than in CMRH because the Swedish occupation data for smaller firms is collected through rolling surveys (the data in CMRH covers the universe of workers). As smaller firms are not sampled every year, following hierarchical structures within firms over time substantially reduces the sample size.

2. Data

2.1. The Swedish occupation data

The Swedish Standard Classification of Occupations 1996 (SSYK) is a national version of the International Standard Classification of Occupations (ISCO-88 (COM)). The SSYK data compiled for the Statistics Sweden LISA database comes primarily from two sources. The first is the official wage statistics survey (Lönestrukturstatistiken) which surveys around 11 000 companies each year in the private sector. Companies with more than 500 workers are surveyed every year; the remainder is a random sample of firms. In total occupation data is gathered for around a million workers each year. The second source is a survey sent out by mail to around 30 000–47 000 companies per year in the private sector who are not selected for inclusion in the official wage statistics survey (a total of around 150 000 private sector companies per year). The surveys are sent out on a rolling basis: all 150 000 companies are surveyed at least once over a 4–5 year time span. Most of these companies have between 2 and 19 workers. In total, summing over the period 2001–2008, between 91% and 96% of all workers in Sweden are sampled at least once.

2.2. Data processing

The sample is based on occupation data in the LISA database and firm accounting data from the Swedish Companies Registration Office available in the IFN Corporate Database (IFNCD).[1] Data on occupation codes, firm–worker links, and labor income of workers comes from the LISA database. CMRH work with hourly wages and number of hours worked; however these are not available in my dataset.[2] I proxy the worker's wage with yearly labor income, which is the sum of an individual's before-tax labor income over the whole year, and hours of work with the number of workers. Information on value added for all firms in the manufacturing sector comes from the IFNCD.

To merge the datasets, I start with the firm-level dataset for the years 2001–2007 and drop duplicated firm-year information (because multiple annual accounts can be submitted each year) and drop observations that have value added or size missing or non-positive. A firm is in the manufacturing sector if it has an SNI2002 categorization at the two digit level between 15 and 37 (the SNI2002 corresponds to the NACE classification at the four digit level). There are 139 064 such firm-year observations.

Around 66% of the workers have "accurate" occupation data. "Accurate" means that the occupation information for the worker is collected in the relevant year from the firm the worker–firm link refers to.[3] Within a surveyed firm, not all workers have accurate occupation data. I keep only firm-year observations with more than 75% of all workers having accurate occupation data and trim away firm-year observations with labor income observations above the 99.95th percentile. The final dataset contains 39 343 firm-year observations corresponding to 95% of value added and 68% of employment in the Swedish manufacturing sector.

Table 1
Wage distribution.

PCS	Mean	$p5$	$p10$	$p25$	$p50$	$p75$	$p90$	$p95$
Class 5+6	267.1	122.4	168.4	219.2	262.5	311.4	366.7	409.4
Class 4	348.1	158.7	201.6	255.9	325.3	418.1	529.3	606.5
Class 3	475.3	216.7	263.6	333.3	426.2	554.3	735.2	887.5
Class 2	520.9	156	198.1	261.7	359.7	594.7	999.3	1359.30
Full sample	307.7	132.5	179.5	229.1	279.9	349.7	458.5	557.5

Notes. This table shows the wage distribution across the four PCS classes that form the basis of layers of management in a firm. The table corresponds to Table 1 in CMRH. Wages are in thousands of 2005 SEK.

2.3. Constructing layers of management

I follow CMRH and use the PCS-ESE classification as basis for layers of management. I use a PCS82 to ISCO-88 mapping and an ISCO-88 to SSYK96 mapping to go from PCS codes to SSYK codes.[4] As CMRH, I use the first digit of the PCS classification to group occupations into four classes. PCS Class 2 corresponds to firm owners receiving a wage (CEO and directors), PCS Class 3 to senior staff/top management positions, PCS Class 4 to supervisors and PCS Class 5+6 to qualified and non-qualified clerical workers and blue-collar workers. Table 1 displays the wage distribution across the PCS occupational categories as applied to the Swedish data. As in CMRH, workers in higher occupations (lower classes) tend to have higher mean and median wages in most parts of the wage distribution.[5]

A firm-year observation with c occupational categories will be said to have $L = c - 1$ layers of management. For example, a firm containing two occupation classes will be said to have one layer of management (a firm can have a maximum of three layers of management).

Table 2 displays the number of firms per year as well as the mean value added, size, wage and layers (size refers to the total number of workers). There is room for firms in Sweden to change by adding or dropping layers: the average number of layers in the firm is similar to CMRH (ranging from 1.2 to 1.6 here and 1.50 to 1.59 in CMRH). The sample size, however, varies quite a bit across time as a result of changes in the sampling of occupations of workers in smaller firms.[6]

[1] See Tåg et al. (2013) for a closer description and summary statistics of the Swedish occupation classifications.

[2] Although not available to me, it is possible to obtain wage and hours' data for a subsample of Swedish workers (those surveyed through "Lönestrukturstatistiken").

[3] For larger firms, the data comes from Lönestrukturstatistiken and is thus "accurate" for every year.

[4] Although the SSYK is based on ISCO-88 (COM), Statistics Sweden note that there are few differences between the ISCO-88 and the ISCO-88 (COM) at the three digit level. The mapping from PCS82 to ISCO-88 comes from EurOccupations.org State-of-the-art report (First Reporting Period-D35) and the ISCO-88 to SSYK96 mapping from Statistics Sweden. When the PCS code corresponds to two or more ISCO-88 codes, I use the highest code (lowest rank) of the ISCO codes for that PCS code.

[5] A difference to CMRH in Table 1 is that Class 2 employees in low percentiles appear to make less money than other classes. A plausible explanation is that CEOs in small Swedish firms are often owners of the firm they work in. CEOs/owners in closely held firms have the option to take out part of their compensation as capital income (through dividends) rather than as labor income (a wage). This is desirable as capital income is taxed at a lower rate than labor income (the "3:12 rules" regulates the portion of income that can be allocated to capital income). The capital income part of the compensation is not reflected in the wage measure in Table 1, so Class 2 employees in low percentiles appear to make less money than other classes.

[6] Firms do not appear to have become flatter over time as in CMRH for France or Rajan and Wulf (2006) for the US. This, however, is likely an artifact of the changes in average size and value added across years because of the sampling of the occupation data.

Table 2
Sample by year.

Year	Firm-year observations	Value added	Mean size	Mean wage	Mean layers of management
2001	7 581	32 378.20	42.1	218.6	1.2
2002	7 444	37 368.60	47.7	233.7	1.4
2003	4 839	60 426.40	70.0	249.2	1.4
2004	4 207	72 412.40	75.8	259.7	1.5
2005	3 822	88 274.80	84.0	271.7	1.6
2006	4 999	76 265.40	66.2	281.4	1.4
2007	6 122	68 445.90	60.2	297.8	1.5
Total	39 014	57 885.30	60.3	255.4	1.4

Notes. This table shows how the sample is spread out over time. It corresponds to Table 2 in CMRH. Size refers to the total number of workers. Value added and wage is in thousands of 2005 SEK.

Table 3
Sample by layer.

Layers	Firm-years	Mean VA	Mean size	Mean wage	Median wage
0	10 347	2 514.70	4.7	223.2	218.1
1	10 908	6 363.80	10.2	241.9	234.9
2	9 361	46 092.70	55.4	269.9	261.4
3	8 398	206 171.30	199.1	296.5	287.1
Full sample	39 014	57 885.30	60.3	255.4	249.8

Notes. This table displays the sample across layers of management (it corresponds to Table 3 in CMRH). Wages and value added (VA) is in thousands of 2005 SEK.

Table 4
Hierarchy in size and wage.

Layers	Size of layers			Mean wage in layers		
	$0 \geq 1$	$1 \geq 2$	$2 \geq 3$	$0 \geq 1$	$1 \geq 2$	$2 \geq 3$
1	95%			82%		
2	89%	79%		82%	82%	
3	88%	70%	95%	87%	87%	88%

Notes. This table displays the percentage of firms that satisfy a hierarchy in number of workers and in mean wages (corresponding to Tables 5 and 6 in CMRH).

3. Analysis

The hierarchies constructed in the data correspond to the theoretical predictions of CMRH and CRH, although the data is noisier than in CMRH. The following three results are all broadly in line with the findings of CMRH for French production hierarchies.[7]

First, firms with more layers are larger in size, in value added, and have higher mean wages. This is apparent from Table 3, which shows the mean of value added, size, and wage across firms with different number of layers.

Second, firms are hierarchical in that lower layers have on average more workers and lower mean wage than higher layers. Table 4 displays the share of firm-year observations for which a layer of management is smaller in size and has a higher mean wage than the layer of management below it. The percentages in Table 4 are similar to the percentages in CMRH, which vary between 54.3% and 85.3% for hours of work and 79.7% and 96.5% for wages. Fig. 1 illustrates the pattern on average for all hierarchy sizes. For each hierarchy size, the mean size of the lower layers is larger than that of the higher layers, and the mean wage of the lower layers is lower than that of the higher layers.

Third, adding layers is on average associated with increases in mean firm size and decreases in mean firm wages at pre-existing layers and the reverse holds for removing layers. This result also holds for layer-by-layer mean layer size and mean layer wages

Table 5
Change in firm-level outcomes.

Variable	All	Increase	No change	Decrease
Δ log (size)	-0.006^{**}	0.105^{***}	-0.006^{**}	-0.114^{**}
– detrended		0.112^{***}	-0.001	-0.107^{***}
Δ log (value added)	0.058^{***}	0.102^{***}	0.057^{***}	0.023^{**}
– detrended		0.045^{***}	-0.002	-0.034^{***}
Δ log (wage)	0.056^{***}	0.080^{***}	0.055^{***}	0.043^{***}
– detrended		0.024^{***}	-0.001	-0.014^{**}
– common	0.056^{***}	0.030^{***}	0.055^{***}	0.093^{***}
– common detrended		-0.026^{***}	-0.001	0.037^{***}
% of firms		12%	76%	12%
% of Δ(value added)		5%	90%	5%

Notes. This table displays the change in firm size, value added, and mean wage for firms that add layers (increase), do not change layers (no change), or remove layers (decrease). It corresponds to Table 13 in CMRH. Statistical significance is based on a t-test of the change in logs being different from zero. Detrending is done by subtracting the mean of yearly changes in the log of the variables.
** Statistical significance is given at the 5% level.
*** Statistical significance is given at the 1% level.

for a majority of pre-existing layers. Table 5 shows the results from computing the log change in total number of workers, value added and mean wage at the firm level separately for firms that increase the number of layers, has no change in the number of layers, or decreases the number of layers.[8] It is based on the 12 340 firm-year observations (31% of the sample) that have two subsequent observations. Adding layers is correlated with increases in size, value added, and mean wages. After detrending the data, removing layers is correlated with reductions in size, value added, and mean wage. However, consistent with CMRH and the theoretical predictions in CRH, mean wages at *pre-existing* layers fall when adding layers and increase when removing layers (after detrending). The share of firms with no change in number of layers is around the same (76%) as in CMRH (73%), but stand for a larger share of change in total value added (90%) than in CMRH (65%). This is likely due to the sampling occupations being biased towards larger firms that see fewer changes in layers. The average effects of changing layers on the mean layer size and mean layer wage in pre-existing layers hold for a majority of individual pre-existing layers as well. CMRH finds that this holds for *all* pre-existing layers in the French data. Here, however, because so few firms are sampled two years in a row the results are less clear. Table 6 displays the mean change in the log of normalized layer size and mean change in the log of mean wage at a layer for different transitions (based on the firms that change layers out of the 31% that can be observed for two consecutive years). A total of 57.5% of the estimates give statistically significant results corresponding to CMRH and 32.5% provide statistically significant results opposite to CMRH.

4. Final remarks

Researchers interested in working directly with the Swedish occupation data could be interested in how to directly construct hierarchies from SSYK occupation codes. The results presented above are similar—sometimes even stronger—using the following SSYK occupation classification:

Class 3: CEOs and directors: SSYK 121 (Directors and chief executives), 131 (Managers of small enterprises), 111 (legislators and senior government officials), and 112 (senior officials of special-interest organizations)

[7] In this section I follow CMRH and do not track individual worker wages, but instead rely on mean wages at the year, firm, layer, firm-layer, year-firm, or year-firm-layer level.

[8] The reasons for the large reduction in the number of observations is the rolling panel feature of the way occupation data is collected.

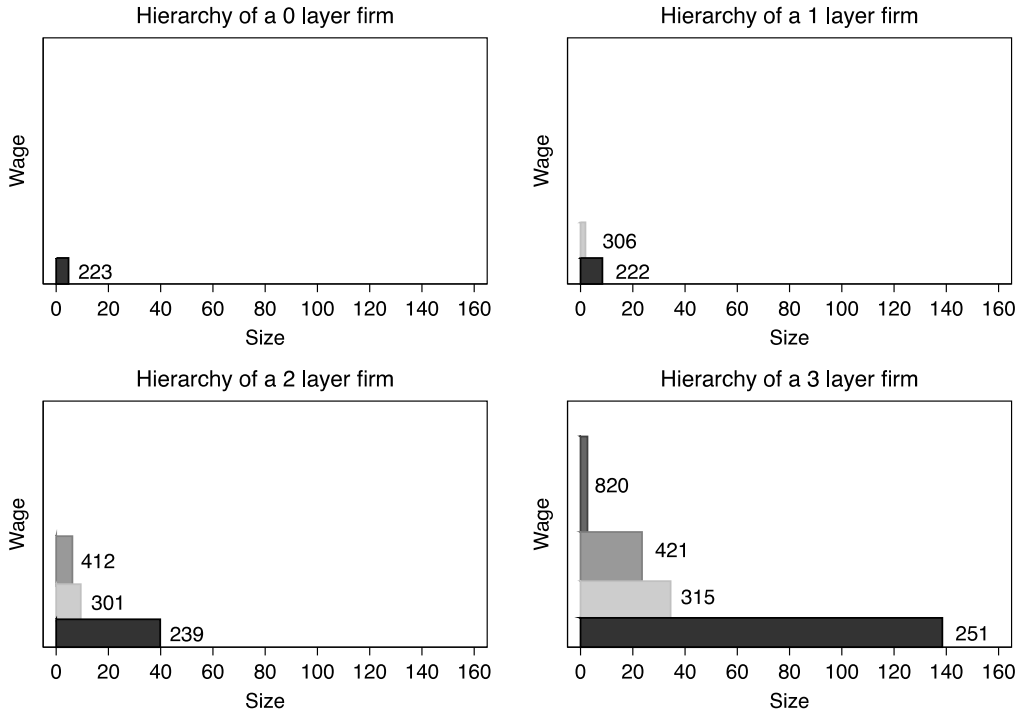

Fig. 1. Size and average wage. This figure displays the mean size and mean wage in each layer of management for all four possible hierarchies (replicating Figure 5 in CMRH). The width of a box corresponds to the mean size of a layer (given on the *x*-axis). The height corresponds to the mean wage in the layer (given next to the box in thousands of 2005 SEK).

Table 6
Changes in layers across transitions.

Layers			Size		Wage		Obs.
Before	After	Layer	Δ log (size)	*p*-value	Δ log (wage)	*p*-value	
0	1	0	*−0.542*	0.000	0.015	0.361	231
0	2	0	*−0.405*	0.007	*0.044*	0.022	49
0	3	0	−0.386	0.733	**−0.238**	0.198	7
1	0	0	*0.338*	0.000	**1.141**	0.000	260
1	2	0	**0.281**	0.000	*0.023*	0.016	396
1	2	1	*−0.385*	0.000	**−0.074**	0.000	396
1	3	0	**0.688**	0.000	0.013	0.454	77
1	3	1	*−0.315*	0.047	**−0.149**	0.001	77
2	0	0	0.360	0.063	**0.146**	0.000	52
2	1	0	**−0.395**	0.000	**0.085**	0.000	383
2	1	1	*0.471*	0.000	**0.231**	0.000	383
2	3	0	**1.174**	0.000	*0.047*	0.000	696
2	3	1	**1.186**	0.000	*0.030*	0.000	696
2	3	2	*−0.120*	0.002	**−0.059**	0.000	696
3	0	0	**−0.047**	0.000	**0.035**	0.000	10
3	1	0	**−0.743**	0.000	**0.096**	0.000	70
3	1	1	*0.0370*	0.001	**0.217**	0.000	70
3	2	0	**−1.356**	0.000	**0.069**	0.000	697
3	2	1	**−1.329**	0.000	**0.083**	0.000	697
3	2	2	*0.140*	0.000	**0.145**	0.000	697

Notes. Mean change in the log of normalized layer size and wage for different transitions. The first and second columns show how layers of management change in the firm, while the third column gives the layer that the remaining columns refer to. This table replicates Tables 14 and 15 in CMRH. Bold values correspond to statistically significant results in line with CMRH, emphasized to statistically significant results opposite to CMRH. The *p*-values are obtained from a regression of the change in log normalized layer size or log wage on a constant (with robust standard errors). The final column reports the number of observations in the regression. Normalization of layer size is done by dividing the size of the layer with the size of the top layer of management.

Class 2: Senior staff: SSYK 122 (Production and operations managers), 123 (Other specialist managers)

Class 1: Supervisors: SSYK 200–399 (Professionals, technicians and associate professionals)

Class 0: Clerks and blue-collars: SSYK 400–999 (Clerks, Service workers and shop sales workers, skilled agricultural and fishery workers, craft and related trades workers, plant and machine operators and assemblers, and elementary occupations).

This classification is useful outside of the production sector as well. Tåg et al. (2013) uses data on all sectors in the Swedish economy and shows that this classification generates hierarchical structures that correspond to theoretical predictions.

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