Productivity dispersion in Dutch manufacturing from 1978 to 2016

Michael Polder
Leen Prenen

CBS Heerlen
CBS-weg 11
6412 EX Heerlen
P.O. Box 4481
6401 CZ Heerlen
+31 45 570 60 00

www.cbs.nl

project number 305397
EBH
September 2020

1. Introduction

In recent work, the OECD provided international evidence showing that there appears to be a growing gap between highly productive and low-productive firms both worldwide (e.g. Andrews et al. 2016), and nationally (Berlingieri et al. 2017, in the context of the MultiProd project). For the Netherlands, the Netherlands Bureau for Economic Policy Analysis (CPB) carried out a study in 2018 that is close to the MultiProd setting, considering the gap between the national frontier and followers (Meijerink et al. 2018; CPB, 2018a and 2018b). For the period 2006-2015, the study concludes that there is no evidence for a widening pattern within the Netherlands for that period. Additional research by Statistics Netherlands (CBS) suggested that the conclusions depend on the reference period, the productivity measure, the dispersion metric, and which industry is looked at (Polder, 2019).

Whether or not there is a growing gap between the front runners, followers and laggards is important for several reasons. Firstly, this could provide an explanation for the moderate and declining productivity growth.[1] Secondly, there may be a relationship between the development of productivity and that of employee remuneration. This could potentially result in a relationship between the widening of productivity and an increasing wage difference between firms, and also with a decrease in the firm-level labour income ratios (Autor et al. 2020).

The aforementioned studies for the Netherlands, as well as most studies for other countries, share the feature that the period of analysis is recent and relatively short. The period of analysis in most studies starts in the early years of the century, which raises the question whether the changes in the productivity dispersion are specific to the last two decades or so, or that the patterns observed are more structural. In fact, a relatively short time series may be one of the reason why it is difficult to establish any divergence in the Netherlands, as in Meijerink et al (2018) who consider the period after 2006 to 2015. For Canada, Gu et al. (2018) provide evidence of an increase in productivity dispersion in manufacturing over the period 1973 to 2015.

Against this background, the Dutch Ministry of Economic Affairs and Climate Policy (EZK), has requested Statistics Netherlands to provide insights into the long run productivity developments of Dutch firms in the manufacturing sector. To this end, data from the Production Statistics are available, for the period from 1978 to 2016.

Section 2 will describe the data. Also the selection of reference years is motivated. Next, section 3 discusses the productivity calculations, and the metrics used. Section 4 describes the main results. Section 5 provides additional results, and discusses the relation to previously reported results. Section 6 summarizes our findings and sketches possibilities for further research.

[1] The actual effect on productivity growth of a possible divergence depends also on the allocation of factor inputs to frontrunners and laggards, as well as on the efficiency of the market selection process (i.e. whether low productivity firms are replaced by more productive ones).

Box 1. Note on comparison to other studies.

It is important to note that the results in the current report are comparable to results from earlier studies to a limited extent:

- The focus is on the manufacturing sector, whereas other studies might include a broader range of economic activities
- Because of data availability, especially regarding the earlier years in this study, only firms with more than 20 employees are considered, whereas other studies might include also smaller firms
- For the same reason, the productivity calculations are based on headcount employment, rather than full-time employment.
- Again for the same reasons, the results in this report are not based on sample weighting as population information is not available for the early years in our sample
- Finally, there are subtle differences in the approach to measuring dispersion, as explained in more detail in section 5.

2. Data

2.1 Production Statistics

The Production Statistics (PS) is a compulsory survey carried out by Statistics Netherlands. The unit of observation is the enterprise, i.e. it is the smallest homogeneous unit of production that can be described in a meaningful way. In this report, we will focus on the manufacturing sector, for which data are available from 1978 onwards.[2] While the size class coverage changes over time and smaller firms are covered incidentally, below it will become clear that the most consistent coverage is for firms with 20 or more employees. The population of all large firms is surveyed, although both large and small firms can be missing in the ultimate sample data due to non-response. Non-response or implausible information is corrected or estimated for the purpose of making aggregate statistics. As these records are less suitable for use in firm-level analyses, they have been excluded in the analysis.

Documentation is scarce for the earlier years of PS data (1978-1998) used in this report. In fact, only variable names are available to us. Based on inspection, and the description in some studies using these data, the following is inferred about the nature of the variables in this period:

- Value added is not at factor cost, and to make it comparable to the post-2000 information, taxes and subsidies were therefore subtracted from the original variable;
- Employment is based on headcount. Our own judgement based on inspection of the microdata is supported by Balk and Hoogenboom-Spijker (2003) and Felsö et al. (2001), who report using headcounts, and which studies are very likely to have used the same dataset as we have available. For reasons of comparability, we use headcounts across the whole period;
- Finally, there is no response label available in the early time-series. Therefore, it is not known whether the sample contains corrections or imputations, which concerns the entry of an estimated value in the case of non-response. In general it can be expected that these concern conservative estimates, and as such, when such observations are indeed included, this will likely result in a conservative assessment of any dispersion. Moreover, Felsö et al. (2001) note that only truly response-based data is available in their dataset, which makes it very likely that any imputations for non-response have been removed in our dataset as well.

The annex presents the time series of the mean and median of all the variables involved in the productivity calculations (value added, persons employed, and depreciation cost). Depreciation cost is available from 1984 onwards, which means that multifactor productivity can be estimated from that year onwards (with depreciation cost as a proxy for the cost of capital services). The series look reasonably smooth over time for this selection of size classes. In some years breaks are observed, and these are not considered in the comparisons made below, as will be explained in the next subsection.

[2] Data for most other sectors are available from 1993 or early 2000s onwards.

2.2 Selection of comparison years

An important thing to take into account when analysing production data over such a long period of time is that the statistical process has changed over time, and the sampling frames can differ across time period. Both aspects may to a certain extent impact directly on the observed firm heterogeneity, such as in productivity.[3] It is therefore crucial to look carefully at the comparability of the data over time.

With respect to changes in the statistical process, we are aware of the following three breaks in the series:

- 2000: Harmonization of production statistics across industries (the so-called "IMPECT" process)
- 2006: Redesign of the business register ("HABR")
- 2009: New production process (NOPS) and new consolidated units of observation ("OG+")[4]

With respect to the sampling frame, smaller firms with less than 20 employees were historically not observed, and only incidentally in more recent years. This is why these firms, corresponding to size class 4 and smaller, are left out of the analyses. This is an important difference with earlier research on the productivity divergence hypothesis (CPB, 2018a and 2018b; Polder, 2019).[5] Thus, the results cannot be compared directly to these studies. In addition, Polder (2019) contains PS-based results based on firms with more than 10, rather than 20, employees as well. Again, these results cannot be directly compared to those here because of the different sample composition. Moreover, for reasons of data availability, we measure employment by headcounts, whereas in the earlier study full-time equivalents and/or hours worked were used, which are not available in pre-1993 data. In section 5.1 we compare the Polder (2019) results with the results of an analysis based on full-time equivalents and including firms with 10 to 20 employees as well, for the period 2006-2015.

[3] For instance, the coverage of small firms is observed to vary over time, which tends to increase the number of relatively low productive firms in the sample and pulls the productivity distribution towards the lower tail. The redesigns of the business register, on the other hand, impact the number of firms considered to be in the population. In general, a larger population will go hand in hand with more heterogeneity.

[4] OG+ was introduced into the Business Register in 2010, but the 2009 PS sample frame was already based on this.

[5] The studies mentioned use the Statistics Finances of Non-Financial Enterprises (SFO, or sometimes abbreviated as NFO). This data source contains data about all enterprises (or, in fact, enterprise groups) in the Netherlands liable to pay corporate income tax. As such, small firms are well-represented in this sources (except for the firms belonging to a natural, self-employed person). However, this source does not go further back than the year 2000, which is an advantage of the data we use in this report. Note that, confusingly, and despite its name, the SFO has data on enterprise *groups*, where the reporting unit in the PS are enterprises.

Figure 1. Number of firms in the sample and coverage across size classes over time.

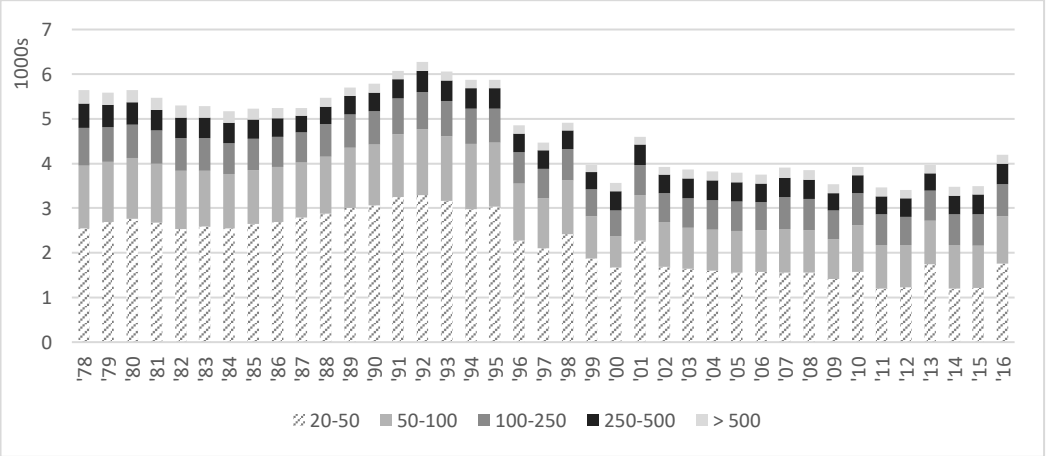


Figure 1 plots the number of firms and the coverage of the firms with 20 or more employees by size class over time. There is a clear drop in the number of firms in the 1999-2000 period, which is likely to be related to the introduction of IMPECT. This makes these years hard to compare to other years. In addition, it is evident that the firm size composition of the sample, especially the share of firms with 20 to 50 employees, varies across the years. Ideally, this is solved by using appropriate sampling weights, which unfortunately are not available for the period before 1994. Especially up to 1995 the number and share of the small firms has been rising, after which it drops and becomes somewhat more volatile up to 2001. Then, from 2002 to 2010 the share is quite stable. After the introduction of OG+, the share of smaller firms became considerably smaller, although 2013 and 2016 are exceptions that seem more comparable to the pre-2010 period.

In terms of comparability, both in terms of number of firms and size class distribution, we therefore suggest to compare the following years:

- 1978 to 1998
- 2002 to 2016

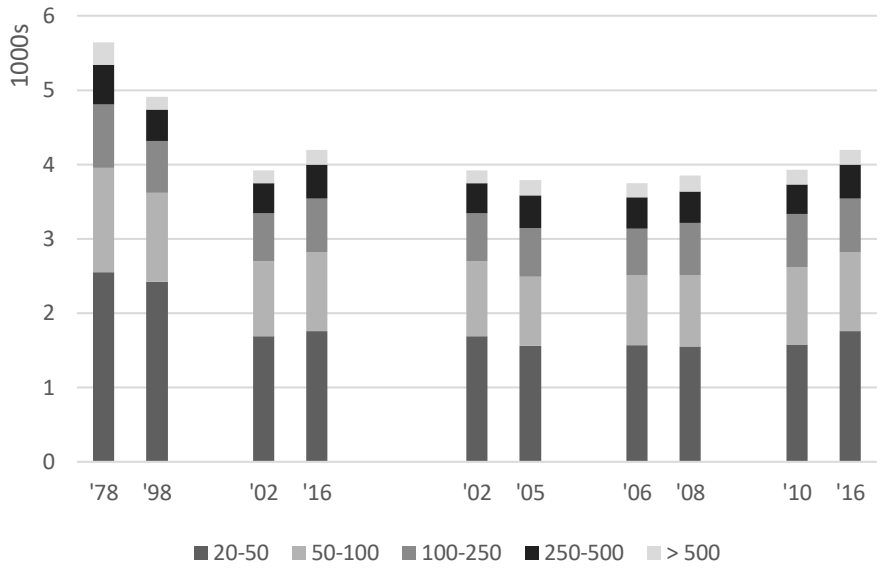
As indicated, the latter period includes three breaks, and to account for this, results are presented for three comparable pairs of years: 2002 to 2005, 2006 to 2008, and 2010 to 2016.

The period 1999-2001 includes the transition to a new production process, and corresponds to a higher volatility in the variables used in the analysis (see the annex). Therefore these years will be discarded.

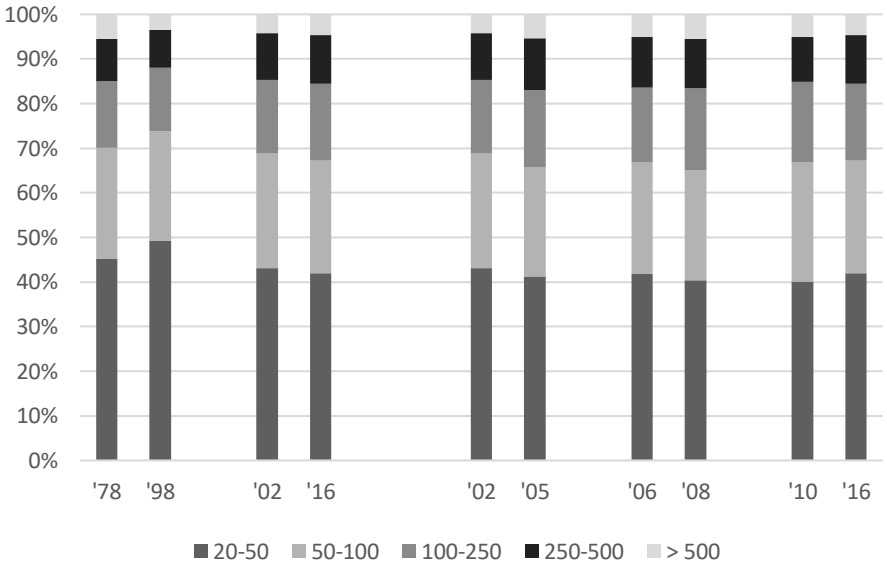
Figure 2 gives the sample size and distribution for all pairs of years of comparison. Overall, the degree of comparability appears to be acceptable. However, it is important to note that it cannot be ruled out that the figures presented are subject to a certain degree of bias or error. For the interpretation of the result one should bear this in mind. In particular, it is advisable to draw conclusions on the broad trends in the data, and not on any individual data points.

Figure 2. Number of firms and coverage across size classes over time: selected years.

(a) Counts.



(b) Shares.



3. Calculation of productivity and dispersion

3.1 Labour productivity

Labour productivity (LP) can be calculated as real value added (RVA) by number of employees (L):

$$LP = \frac{RVA}{L}$$

The measures of spread that are used in this analysis is the deviation of the productivity of the top and bottom 10 percent of the distribution ($p90$ and $p10$), with respect to the median ($p50$):

$$LP(p90/p50) = LP(p90)/LP(p50)$$
$$LP(p50/p10) = LP(p50)/LP(p10)$$

By definition, the top decile to bottom decile ratio is the product of the previous ratios:

$$LP(p90/p10) = LP(p90/p50) \times LP(p50/p10).$$

The use of ratios avoids the need to use of deflators under the (standard) assumption that prices do not differ within an industry. To see this, note that nominal value added for firm i in year t is defined as

$$VA_{it} = p_{it}q_{it}$$

where p_{it} and q_{it} are the price and quantity component of value added. Real value added in terms of the prices of some base year 0 would be

$$RVA_{it} = p_{i0}q_{it}$$

When prices are equal within a certain industry, $p_{it} = p_t$ and $p_{i0} = p_0$, for each firm i in the same industry, and supressing the industry subscript for convenience. Then, when the reference median firm is part of the same industry as the top and bottom decile firms, the price component cancels out, both in the ratio based on real and nominal value added. For instance, for the top-median ratio:

$$\frac{RVA_{p90,t}}{RVA_{p50,t}} = \frac{p_0 q_{p90,t}}{p_0 q_{p50,t}} = \frac{q_{p90,t}}{q_{p50,t}}$$
$$\frac{VA_{p90,t}}{VA_{p50,t}} = \frac{p_t q_{p90,t}}{p_t q_{p50,t}} = \frac{q_{p90,t}}{q_{p50,t}}$$

and similarly for any other ratios. Therefore, for the purpose of this analysis, it does not matter whether nominal or real (i.e. deflated) value added is used, and the use of industry price deflators is circumvented.

3.2 Multifactor productivity

There are various ways to determine multifactor productivity (MFP). We will use a value added based approach, in which labour (L) and capital (K) are the two relevant factors of production. A choice has to be made how to combine the services of these components into an index of the total use of production factors. A standard way of doing so is to assume a Cobb-Douglas index:

$$RVA = f(K, L) = A \cdot K^{(1-\alpha)} L^{\alpha}$$

where A is the MFP-term and α is the labour share. For now, K and L can be thought of as the volume of capital and labour, however measured. We will come back to this below. For later reference, note that labour productivity can be decomposed into a contribution of MFP and capital intensity:

$$LP = \frac{RVA}{L} = A \cdot \left(\frac{K}{L}\right)^{(1-\alpha)}$$

Ideally, we would observe the share of labour in the total cost of production. However, as the cost of capital services cannot be derived from the firm-level data, we will approximate it using its value added share (where this approximation is exact under standard neo-classical assumptions). In addition, to avoid strange outcomes at the firm-level, we will assume that the structure of production is similar across firms performing a similar economic activity j, and therefore use the labour share at the industry-level. Assuming constant returns to scale, the capital share is determined as 1 minus the (industry) labour share.

As with labour productivity, when a firm's MFP is denominated on the median firm in its industry, it does not matter whether we use the real or nominal value for value added. Moreover, the same holds for capital services, which we proxy by depreciation. That is, in the denominator of the MFP term we find $K^{(1-\alpha)}$, so when r denotes the unit user cost,

$$\frac{\left(rK_{p90}\right)^{(1-\alpha)}}{\left(rK_{p50}\right)^{(1-\alpha)}} = \left(K_{p90}/K_{p50}\right)^{(1-\alpha)}$$

and therefore the ratio is invariant to using base or current year prices.

The relative MFP levels can be expressed as the relative output divided by geometric average of the relative input levels:

$$MFP\left(\frac{p90}{p50}\right) = \frac{A_{p90}}{A_{p50}} = \frac{RVA_{p90}/RVA_{p50,t}}{{K_{p90}}^{1-\alpha}{L_{p90}}^{\alpha}/{K_{p50}}^{1-\alpha}{L_{p50}}^{\alpha}}$$
$$= \frac{VA_{p90}/VA_{p50,t}}{(K_{p90}/K_{p50})^{1-\alpha}(L_{p90}/L_{p50})^{\alpha}}$$

where value added and capital cost can be used in nominal terms.

Finally, since we are looking at relative levels of productivity, the scale of the capital and labour input measures is also irrelevant. That is, for capital inputs, we use depreciation cost, which should be the major component of the total cost of capital services, but there are other

components as well, such as opportunity cost. The implicit assumption here is that the share of depreciation cost in the total cost of capital services is more or less equal across firms within the same industry, so that if we look at the ratio of the depreciation cost of two firms, it is an adequate approximation of the relative level capital inputs. For labour, we observe headcounts, and the assumption is that the ratio of headcount between two firms, is similar to the hours worked ratio.

3.3 Calculation and pooling

All calculations are carried out, in principle, at the subindustry level. In exceptional cases, less than 5 firms are observed in particular industries, in which case these observations are dropped. In some other cases, small industries were merged with another related industry; see table A1 in the annex for the aggregates used.

Besides avoiding the use of deflators, normalizing on the median firm by two-digit sub-industry controls for productivity differences between these industries. That is, denominating by the median of the annual distribution, brings all subindustry productivity distributions around a median of 1. Moreover, as this is done every year, there is no growth in the median productivity, and thus we focus only on (changes in) the dispersion. And to be precise, changes in the composition to higher or lower productive economic activities within the manufacturing sector do not impact our results (this is an important deviation from other studies; see also section 5.1).

While the calculations are done at the subindustry level, the results are presented for total manufacturing. It is important to note that there is no aggregation, in the sense that we do not sum up productivity or its components. Instead, we consider the productivity relative to the subindustry medians as our variable of interest, and pool the firm-level observations in all of the subindustries together. This gives a new "(subindustry) median-normalized" productivity distribution for the overall manufacturing sector, for which we determine the dispersion metrics.

3.4 Metrics for the change in dispersion

The research question in this report is whether the dispersion of productivity has increased over time. As described above, to measure the dispersion in a given year, the relative differences between the median, and the top and bottom decile are used. The change of these ratios over time can be determined in a relative way (in percentages), or in an absolute sense (in percentage points). Consider a case where the top-median ratio has increased from 2 to 2.1. Then the dispersion has increased by 5%, or 10 percentage points. Referring to the actual results in table 1, if the labour productivity top-median ratio is 1.57 in 1978 and 1.72 in 1998, the increase in *the ratio* is about 10% or 15 percentage points. However, in 1978 the top firms were 57% more productive than the median firm. In 1998 this had increased to 72%, which could also be reported as a 28% increase of *the gap*.[6] Thus, the change in the ratio of 10%

[6] The respective ratios in 1978 and 1998 are in fact 1.568 and 1.725. Thus in 1978 the top firms were 56,8% more productive than the median firm. The absolute change in the gap is 15.7, which is 27,6% of the initial 56,8%.

seems to suggest a much more conservative picture. This should be borne in mind in the interpretation. The percentage point change is not affected by this issue.

In line with the above, we will present several metrics in the results section:

1. Dispersion ratios in *levels*, for the years which are most comparable in terms of sample size and size class coverage, e.g. $\frac{LP_t(p90)}{LP_t(p50)}$
2. Percentage change in the dispersion ratios, e.g. $\left(\frac{LP_t(p90)}{LP_t(p50)}\right)/\left(\frac{LP_0(p90)}{LP_0(p50)}\right) - 1$
3. Percentage point change in the dispersion ratios, e.g. $\frac{LP_t(p90)}{LP_t(p50)} - \frac{LP_0(p90)}{LP_0(p50)}$
4. Percentage change with respect to the initial gap, e.g. (3)/($\frac{LP_0(p90)}{LP_0(p50)} - 1$)

We refer to 2. as the "change in the dispersion ratio", and to 4. as the "change in the gap". Note that the gap is the dispersion ratio minus 1. Box 2 contains a numerical illustration of the metrics, and a parallel to income in terms of interpretation.

In some previous studies, the metric used is not the change in the dispersion ratios, but the absolute difference of the changes in the quantiles with respect to the base year, for instance the relative change in $p90$ minus the relative change in $p10$. This is in fact equivalent to the relative change in the dispersion ratios that we report (metric 2). To see this, note that the percentual change in the dispersion rates is approximately equal to the log of the relative change

$$\left(\frac{LP_t(p90)}{LP_t(p10)}\right)/\left(\frac{LP_0(p90)}{LP_0(p10)}\right) - 1 \approx \ln\left(\left(\frac{LP_t(p90)}{LP_t(p10)}\right)/\left(\frac{LP_0(p90)}{LP_0(p10)}\right)\right)$$

which can then be rearranged, and written as the log difference of the change in the respective quantiles (note that we rewrite from p90/p10 ratios to changes in p90 and p10 here)

$$\ln\left(\left(\frac{LP_t(p90)}{LP_0(p90)}\right)/\left(\frac{LP_t(p10)}{LP_0(p10)}\right)\right) = \ln\left(\frac{LP_t(p90)}{LP_0(p90)}\right) - \ln\left(\frac{LP_t(p10)}{LP_0(p10)}\right)$$

Finally, this can be written as the percentage point difference between the changes in the quantiles:

$$\ln\left(\frac{LP_t(p90)}{LP_0(p90)}\right) - \ln\left(\frac{LP_t(p10)}{LP_0(p10)}\right) = \left(\ln\left(\frac{LP_t(p90)}{LP_0(p90)}\right) + 1\right) - \left(\ln\left(\frac{LP_t(p10)}{LP_0(p10)}\right) + 1\right)$$

$$\approx \frac{LP_t(p90)}{LP_0(p90)} - \frac{LP_0(p10)}{LP_0(p10)}$$

The log difference approximation works well as long as the changes or ratios are close to 1; note that it is more accurate to work with the actual relative changes in the dispersion ratios, as we do in this paper, as the period of analysis becomes longer and cumulative changes over time become larger. (That said, the absolute difference of the changes in the quantiles could also be regarded as yet another metric for the change in dispersion.)

Box 2. Illustration of the different metrics

By way of illustration, suppose that the top decile productivity increases from 15 to 20, and the bottom decile from 10 to 12. In this case, the dispersion ratio is 1.5 in the first period, and 1.66 in the second (metric 1). The percentage change is 10.7% (metric 2). The percentage point change is 16 (metric 3), which is a 32% increase of the initial gap (metric 4, the initial gap being 50%). As in the example of section 3.3, it seems that (3) and (4) suggest a stronger increase in the dispersion, while in fact they are alternative ways of presenting the same.

In previous studies, the dispersion and its change have been reported in terms of 1. and 2. (or, equivalently in terms of changes in log differences of productivity).[7] It is helpful to draw a parallel to relative income. If person A earns 10% more than person B at some point in time, and 15% more in a later period, we could say that the income dispersion has increased by 4.5% or 5 percentage points. However, the magnitude of the increase sounds a lot more urgent when we point out that at the same time it is true that the income gap has increased by 50%. (In terms of a modal income of 36.000 euro, the gap would increase from 3600 euro to 5400 euro. Though not incorrect, it seems less intuitive to summarize this as a 4.5% increase of the dispersion.)

[7] See the derivation in the main text of this section.

4. Results

This section presents the results of the various calculations. While there may be substantial margin around these figures, the magnitude and consistency of the findings over time, point into the direction of a structural long-term increase in the dispersion of productivity in the manufacturing sector.

For the sake of clarity, the discussion is focussed on the top-median and top-bottom differences. The median-bottom differences are presented in the tables as well, and can be checked by the reader. Note that the change in the top-bottom dispersion ratio is the change in the top-median ratio times that in the median-bottom ratio.

Although the figures presented are in our view sufficiently comparable across the years reported, we advise that they are not used or interpreted in an absolute sense. As pointed out above, the comparability between years is impacted by changes in the production process, especially in the second period. Moreover, for comparability across the entire period, productivity is based on headcount of employees, which is a somewhat rough measure of labour input, although a comparison to the results of calculations based on full-time equivalents for the second period, points out that this does not change any of the qualitative conclusions. We also note that due to the omission of the 2005-2006 and 2008-2009 transitions, the 2002-2016 changes cannot be calculated from the subperiod figures presented in the table.

Finally, while the long-term patterns are plausible, in the second period we observe a high volatility in the capital intensity measure used, resulting in relatively strong changes in the dispersion of capital intensity in the subperiod breakdown of the second period. While the patterns observed for MFP are not that volatile or implausible for these subperiods, it is wise to interpret them with caution as these are impacted by the capital intensity pattern.

4.1 Labour productivity

Table 1a shows the results for labour productivity. In the 1978-1998 period the labour productivity dispersion ratio increases from 1.57 to 1.72, that is by 10% or 15.7 percentage point. In terms of the initial gap (57%), the increase of 15.7 percentage points is 27.6%. The top-median ratio has increased by 0.5% per year on average; the corresponding gap has increased on average by 1.2% per year. The top-bottom ratio has seen a stronger increase with 0.7% per year on average, while the corresponding gap increased by 1.2% per year on average as well.

In the second period of the analysis, 2002-2016, the increase in the top-median dispersion ratio is similar to the first period with 0.5% on average per year, or 1.1% in terms of the gap. The top-bottom ratio increased in a slightly stronger fashion, both compared to the top-median as well as to the first period, with 1.2% on average per year, or 1.8% in terms of the gap.

The increase in the dispersion is especially strong in the first half of the second period, the only exception being the top-median ratio between 2002-2005. Especially the top-bottom ratio increase between 2006 and 2008 is relatively strong with 3.2% yearly on average. However, we observe that for this period the results in terms of headcount differ substantially from those using full-time equivalents (fte). From table A2 it can be seen that the increase is 1.2% yearly on average when using fte in the labour productivity calculation, which is a similar figure as for the

other subperiods. In most instances, the results based on headcount and fte are much more in line, and ultimately, they point into the same direction of a longer term widening of the productivity distribution.

Overall, these results suggest a structural increase of the dispersion in the labour productivity across the whole period considered. Disregarding the 1999-2001 period, the results imply an increase of the top-median dispersion ratio of 18%, or 0.5% annual. The corresponding top-median *gap* increased by 48%, or 1.2% annually on average.

The increase in the top-bottom ratio was substantially higher than that of the top-median ratio, with 37% in total, or 0.9% annual on average. In terms of the gap this is 1.4% annually, amounting to a (virtually) 62% bigger gap in 2016, as compared to 1978. This is the result of an increase in both the top-median as well as the median-bottom ratios. The increasing difference between the top and the bottom does not seem to be due to a specific part of the distribution, however, as the figures suggest that the increases in the top-median and median-bottom ratios contributed to a similar extent.

Table 1a. Labour productivity dispersion ratios and various metrics of change, by period.

1. Dispersion ratios

	top-median	median-bottom	top-bottom
1978	1,57	1,53	2,4
1984	1,57	1,51	2,4
1998	1,72	1,61	2,8
2002	1,79	1,68	3,0
2005	1,82	1,75	3,2
2006	1,82	1,82	3,3
2008	1,88	1,87	3,5
2010	1,85	1,77	3,3
2016	1,92	1,85	3,6

2. Percentage change in dispersion ratios

	top-median		median-bottom		top-bottom	
	%	(av.)	%	(av.)	%	(av.)
1978-1998	10,0	(0,5)	5,3	(0,3)	15,9	(0,7)
1984-1998	9,6	(0,7)	6,8	(0,5)	17,1	1,1)
2002-2016	7,1	(0,5)	10,5	(0,7)	18,4	(1,2)
2002-2005	1,4	(0,5)	4,0	(1,3)	5,5	(1,8)
2006-2008	3,8	(1,9)	2,6	(1,3)	6,5	(3,2)
2010-2016	3,7	(0,6)	4,5	(0,7)	8,4	(1,4)

3. Percentage point change in dispersion ratios

	top-median		median-bottom		top-bottom	
	Δ	(av.)	Δ	(av.)	Δ	(av.)
1978-1998	15,7	(0,8)	8,1	(0,4)	38,0	(1,9)
1984-1998	15,1	(1,1)	10,3	0,7)	40,5	2,9)
2002-2016	12,8	(0,9)	17,6	(1,3)	55,2	(3,9)
2002-2005	2,5	(0,8)	6,7	(2,2)	16,5	(5,5)
2006-2008	6,8	(3,4)	4,8	(2,4)	21,5	(10,8)
2010-2016	6,9	(1,2)	8,0	(1,3)	27,6	(4,6)

4. Percentage change relative to the initial gap

	top-median		median-bottom		top-bottom	
	%	(av.)	%	(av.)	%	(av.)
1978-1998	27,6	(1,2)	15,4	(0,7)	27,2	(1,2)
1984-1998	26,3	(1,7)	20,3	(1,3)	29,5	(1,9)
2002-2016	16,1	(1,1)	25,9	(1,7)	27,5	(1,8)
2002-2005	3,2	(1,1)	9,9	(3,2)	8,2	(2,7)
2006-2008	8,4	(4,1)	5,9	(2,9)	9,3	(4,6)
2010-2016	8,1	(1,3)	10,4	(1,7)	12,1	(1,9)

Table 1b. Multifactor productivity dispersion ratios and various metrics of change, by period.

1. Dispersion ratios

	top-median	median-bottom	top-bottom
1978			
1984	1,51	1,42	2,1
1998	1,64	1,49	2,4
2002	1,66	1,58	2,6
2005	1,75	1,62	2,8
2006	1,82	1,62	2,9
2008	1,85	1,66	3,1
2010	1,82	1,65	3,0
2016	1,86	1,68	3,1

2. Percentage change in dispersion ratios

	top-median			median-bottom			top-bottom		
	%	(	av.)	%	(	av.)	%	(	av.)
1978-1998		(	)		(	)		(	)
1984-1998	8,8	(	0,6)	4,9	(	0,3)	14,1	(	0,9)
2002-2016	12,2	(	0,8)	6,2	(	0,4)	19,2	(	1,3)
2002-2005	5,5	(	1,8)	2,8	(	0,9)	8,5	(	2,8)
2006-2008	1,7	(	0,8)	2,5	(	1,2)	4,2	(	2,1)
2010-2016	2,4	(	0,4)	1,7	(	0,3)	4,2	(	0,7)

3. Percentage point change in dispersion ratios

	top-median			median-bottom			top-bottom		
	Δ	(	av.)	Δ	(	av.)	Δ	(	av.)
1978-1998		(	)		(	)		(	)
1984-1998	13,3	(	0,9)	6,9	(	0,5)	30,1	(	2,2)
2002-2016	20,2	(	1,4)	9,8	(	0,7)	50,2	(	3,6)
2002-2005	9,1	(	3,0)	4,5	(	1,5)	22,2	(	7,4)
2006-2008	3,0	(	1,5)	4,0	(	2,0)	12,3	(	6,2)
2010-2016	4,4	(	0,7)	2,9	(	0,5)	12,6	(	2,1)

4. Percentage change relative to the initial gap

	top-median			median-bottom			top-bottom		
	%	(	av.)	%	(	av.)	%	(	av.)
1978-1998		(	)		(	)		(	)
1984-1998	26,0	(	1,7)	16,6	(	1,1)	26,4	(	1,7)
2002-2016	30,7	(	1,9)	17,0	(	1,1)	31,0	(	1,9)
2002-2005	13,8	(	4,4)	7,8	(	2,5)	13,7	(	4,4)
2006-2008	3,7	(	1,8)	6,5	(	3,2)	6,4	(	3,1)
2010-2016	5,4	(	0,9)	4,5	(	0,7)	6,3	(	1,0)

4.2 Multifactor productivity

Looking at MFP, the results in table 1b for the 1984-1998 period are quite similar to the results for labour productivity for the same period (reported in table 1a), although the increases of the dispersion ratios and the gaps are slightly lower overall. The top-median dispersion ratio increased by 0.6% yearly on average, compared to 0.9% for the top-bottom ratio. For the 2002-2016 period, this was 0.8% yearly on average for the top-median dispersion ratio, and 1.3% for the top-bottom ratio, which is slightly higher than for labour productivity. The increases of the corresponding gaps are again more substantial with 1.7% yearly on average for both the top-

median and top-bottom ratio in the first period, compared to 1.9% in the second period, again for both types of ratios.

For the full period, and again discarding the years from 1999 to 2001, the figures imply a change of the top-median dispersion ratio of 22%, and 36% for top-bottom, respectively 0.7 and 1.1% per annum on average. The respective gaps both grew by 1.8% yearly on average, amounting to an overall increase of 65%. Compared to labour productivity, the increase in the top-median MFP difference is somewhat stronger, whereas the increase for the top-bottom difference is comparable.

4.3 Capital intensity

For completeness, we also present the dispersion of capital intensity over time. As shown in section 3.2, at the firm-level, labour productivity can be decomposed into a contribution of MFP and capital intensity:

$$LP = \frac{RVA}{L} = A \cdot \left(\frac{K}{L}\right)^{(1-\alpha)}$$

However, this exact decomposition cannot be derived from the figures presented in the tables. Firstly, capital intensity has to be weighted with the capital share $(1-\alpha)$, and this is (sub-industry) specific. Secondly, the ordering of firms in the distributions of labour productivity, MFP and capital intensity is different, e.g. a firm in the top decile of capital intensity, does not necessarily have to be in the top deciles of MFP, or vice versa. This means that the medians and percentiles reported refer to different firms, and therefore the equation does not hold when one would want to decompose for instance frontier labour productivity into frontier capital intensity and MFP. Nevertheless, it is informative to show the change in dispersion of capital intensity, as it gives an idea of whether the change in dispersion for labour productivity could be driven by this or not.

The results in table 1c suggest that in the first period the dispersion in capital intensity was rather stable, with a small decrease of the top-median ratio, and slight increases in the median-bottom and top-bottom ratios. In the second period, the overall changes were more substantial, with 0.5% annual increase of the top-median ratio on average, up to a 2% annual increase for the top-bottom ratio.

While the results for the second period as a whole seem plausible, the subperiod breakdown shows substantial volatility, especially in the 2002-2005 period, but also in the other subperiods. As already mentioned above, the results for the second period, especially the breakdown into subperiods, should be interpreted with care for both the capital intensity, and for MFP, which is partly based on the capital intensity. Some preliminary investigation into this issue suggests that especially the capital intensity in the group of smallest firms (20 to 50 employees) looks more volatile.

Table 1c. Capital intensity dispersion ratios and various metrics of change, by period.

1. Dispersion ratios

	top-median	median-bottom	top-bottom
1978			
1984	2,61	2,88	7,5
1998	2,55	2,97	7,6
2002	2,78	3,06	8,5
2005	3,03	3,72	11,3
2006	3,07	3,60	11,1
2008	3,16	3,82	12,0
2010	2,82	3,26	9,2
2016	2,99	3,75	11,2

2. Percentage change in dispersion ratios

	top-median			median-bottom			top-bottom		
	%	(	av.)	%	(	av.)	%	(	av.)
1978-1998		(	)		(	)		(	)
1984-1998	-2,1	(	-0,2)	3,3	(	0,2)	1,1	(	0,1)
2002-2016	7,4	(	0,5)	22,3	(	1,4)	31,4	(	2,0)
2002-2005	8,8	(	2,9)	21,6	(	6,7)	32,3	(	9,8)
2006-2008	2,9	(	1,4)	5,8	(	2,9)	8,9	(	4,4)
2010-2016	6,1	(	1,0)	14,8	(	2,3)	21,7	(	3,3)

3. Percentage point change in dispersion ratios

	top-median			median-bottom			top-bottom		
	Δ	(	av.)	Δ	(	av.)	Δ	(	av.)
1978-1998		(	)		(	)		(	)
1984-1998	-5,6	(	-0,4)	9,4	(	0,7)	8,0	(	0,6)
2002-2016	20,7	(	1,5)	68,3	(	4,9)	267,8	(	19,1)
2002-2005	24,5	(	8,2)	66,0	(	22,0)	274,9	(	91,6)
2006-2008	8,9	(	4,5)	21,0	(	10,5)	98,5	(	49,3)
2010-2016	17,1	(	2,8)	48,3	(	8,0)	200,1	(	33,3)

4. Percentage change relative to the initial gap

	top-median			median-bottom			top-bottom		
	%	(	av.)	%	(	av.)	%	(	av.)
1978-1998		(	)		(	)		(	)
1984-1998	-3,5	(	-0,3)	5,0	(	0,4)	1,2	(	0,1)
2002-2016	11,6	(	0,8)	33,1	(	2,1)	35,6	(	2,2)
2002-2005	13,7	(	4,4)	32,0	(	9,7)	36,6	(	10,9)
2006-2008	4,3	(	2,1)	8,1	(	4,0)	9,8	(	4,8)
2010-2016	9,4	(	1,5)	21,3	(	3,3)	24,4	(	3,7)

5. Additional analyses

5.1 Relation to earlier results on productivity dispersion

In the report "Comparing productivity patterns across different sources" (Polder, 2019) results were presented for the productivity dispersion based on the Production Statistics and Statistics Finances of Non-Financial Enterprises (NFO/SFO). These results were obtained using the MultiProd protocol as set up by the OECD (see Berlingieri et al. 2017), and concerned the period 2006-2015. The main results in that report, that were also used in Roelandt et al. (2019), were based not on the PS as in this report, but on the SFO.

In this section we describe the relation of the earlier PS-based results to those in the current report.

The most important insight is that the analysis in the current report is different in nature from the analysis on which the MultiProd results for manufacturing are based. We explain this in more detail in Box 3. In short, one could say the following. The analysis in this report (based on figures denominated by subindustry medians) focusses on the changes in the dispersion *within* subsectors, as described in section 3. In the case of the earlier MultiProd study, deflating at the subsector level combined with reporting at a more aggregate level (as in the previous report), combines changes in dispersion within subsectors with changes in differences *between* subsectors with respect to the median. That is, changes in the subindustry medians, do not have an impact on the results in the current report, whereas in the previous report they do.

Besides this more fundamental difference in the type of calculations, the results differ in the selection of firms. The results presented in the *current* report pertain to the firms with 20 or more persons employed, and are based on headcount employment and unweighted.[8] The *previous* report did not provide results for exactly these settings, but for the sample of 10 or more persons employed, where employment concerned fte. For completeness, we present here a replication of the labour productivity analysis in the current report for the sample of 10 or more persons for the more recent period.[9]

[8] In previous analyses, controlling for outliers was found not to impact the results, as using percentiles is not that sensitive to potential extreme values. We do not use weighting here, as we do not have population figures before 1993. However, from years where we do have the population figures, we know that the coverage of firms with more than 20 employees is quite high with up to around 80%.

[9] As noted above, the earlier years of our PS data do not allow for this possibility, as firms with 10 to 20 employees are not covered in a consistent way.

Box 3. Differences between current and previous analyses

Productivity is usually calculated based on real output which is obtained by transforming nominal into real values using price deflators at the industry level. This then results in productivity figures for a set of firms, and a distribution of labour productivity for, for instance, the manufacturing sector. The median, and top and bottom deciles, are the statistics that have been used to summarize the dispersion of the distributions by year in previous reports. The level of aggregation at which the results are presented, does not necessarily have to correspond to the level at which the deflators have been applied.

However, each subindustry has its own productivity distribution, with a corresponding median and percentiles. In this report, we exploit the assumption that the deflators used are the same for firms within a group, in our case the two-digit subindustry, to note that the top-median and median-bottom ratios do not require explicit deflation (as the deflator cancels out in the ratio, see section 3). Firm productivity in each subsector is effectively denominated by the corresponding median, or in other words, the productivity of each firm is relative to the median of this subsector. Combining the firm-level figures for the subsectors, we obtain a distribution of denominated productivity figures for manufacturing as a whole. The dispersion ratios of this distribution, and their changes over time, are analysed in this report.[10]

At the subindustry level, then, deflation and denomination provide the same dispersion ratios, so the two approaches are equivalent. However, the results reported are not reported at the subindustry level, but at the level of the entire manufacturing sector, and this leads to differences. The reason is that as soon as the observations of firms from the different subsectors are combined, the two approaches result in a different sorting of firms, and therefore different medians and percentiles. For instance, in the denominated distributions all medians are scaled to unity, whereas with deflation, the medians by subsector differ, and end up in different parts of the overall distribution. Consequently, for instance, shifts in the subindustry distribution that affect the median but not the dispersion, would not affect the overall denominated distribution, but for the deflated figures it does affect the overall distribution and dispersion. One could therefore say that the analysis based on denominated figures as in this report focusses on only the changes in the dispersion *within* subsectors, whereas deflating at the subsector level (and reporting at a more aggregate level) combines changes in dispersion within subsectors, with changes in differences *between* subsectors.

By way of example, consider the case where in a certain subindustry (say, the chemical industry) all firms become equally more productive (raising the median, but not the dispersion), whereas in another subindustry (apparel), firms remain at the same level of productivity. In this case, the dispersion within the manufacturing sector as a whole increases due to a shift of the productivity distribution of the chemical industry with respect to the apparel industry. This source of change in the dispersion is captured by looking at the deflated figures, while the denominated productivity analysis controls for these changes and only monitors changes in dispersion within subsectors.

[10] Note that, de facto, the median of all subsector denominated distributions, and therefore of the distribution for manufacturing as a whole, is equal to unity. Therefore, the dispersion measures are in fact equal to the top and bottom deciles of the denominated distribution.

Figure 3. Comparison of current results to PS-based MultiProd results (labour productivity)

a. Comparison of the dispersion ratios for the samples with at least 10 and 20 employees (2006 = 1).

b. Comparison of dispersion ratios using current approach and PS based MultiProd results for firms with at least 10 employees (2006 = 1).

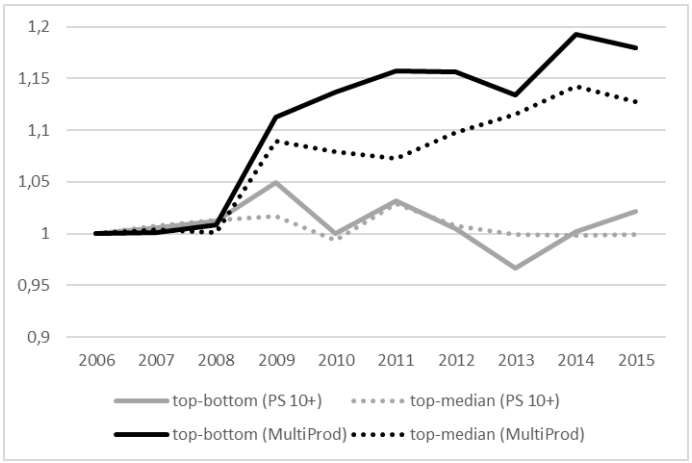


Figure 3a compares the results of the development of the dispersion ratios for the samples of firms with more than 10 and 20 employees respectively. It is clear that the top-median dispersion develops similarly, regardless of whether 10 to 20 employee firms are included or not. The volatility in the top-bottom dispersion is slightly higher in the 20-plus sample, but the direction of the changes are similar.

As for the comparison to the PS-based results following from the MultiProd program, figure 3b shows that the latter show a much stronger widening, especially between the top and the median (and consequently also between the top and bottom, while the median-bottom difference remained quite stable). The main candidate explanation for this difference is the different nature of the calculations, as described above. In essence, the MultiProd results reflect also a possible divergence between sub-industries of manufacturing, where the results in this report do not.[11]

[11] To some extent, the patterns based on nominal figures in section 5.2 confirm this interpretation.

Thus, the difference between the two sets of results is likely to be driven by increased productivity differences between subindustries. As the main divergence seems to have taken place in 2009, an interesting but tentative conclusion would be that the productivity distribution of manufacturing subindustries responded to the financial crisis in a different way. This is an interesting question for further research.

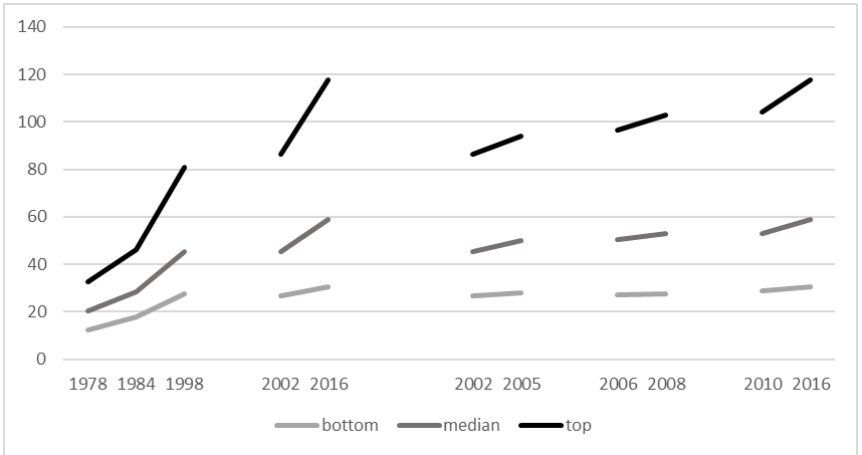
A final but important caveat to the interpretation of figure 3 is that in this paper we have argued that not all years are strictly comparable in terms of coverage of firms of different sizes. Therefore, at least some of the variation over time of the figures presented in figure 3 stems from these differences in coverage. In particular, the comparison period ends in 2015, which we deem less comparable to the years at the beginning of the comparison period in terms of number of firms and size class coverage.

5.2 Nominal changes in value added per headcount employees

The denomination on the median that was applied in our analysis does not allow to discern the separate development of the quantiles of the productivity distributions. To give some insight into this, figure 4 reports the nominal changes in the median, top decile and bottom decile of value added per headcount employee. Thus, in this figure, changes in prices are not taken into account, and the figures are not normalized on the subindustry medians. The median shown is the median of total manufacturing. While strictly speaking real instead of nominal values should be used for productivity, it allows to assess the discern the changes in the different parts of the distribution of the value added to employment ratio. In addition, the within and between sector changes in productivity affect these results, which can be used as a check whether this indeed explains the differences with the MultiProd results as suggested in section 5.1.

The main takeaway from this figure is that for all periods and subperiods considered in this report, it holds that the rate of increase is higher for the top decile than for the median, and higher for the median than for the bottom. Strikingly, all quantiles show an increase, but to a stronger degree when moving up along the distribution, suggesting that most of the increase in dispersion comes from a stronger growth at the top. Moreover, the results seem to be more in line with the MultiProd figures, presumably because of the effect of within and between sector shifts in productivity, as discussed in 5.1.

Figure 4. Nominal value added (in €) per headcount for manufacturing over time.



6. Summary and suggestions for further research

In this report the productivity dispersion in Dutch manufacturing was investigated over the period 1978 to 2016. Based on the Production Statistics, the results provide evidence for a long-term structural widening of the productivity distribution, both in labour productivity and MFP. This widening occurred to a similar degree both in the period before and after 2000, although it tends to be somewhat stronger in the post-2000 period. Finally, the widening seems to occur in all parts of the distribution, with increasing differences between the top, median, and bottom, although the strongest in the top-bottom gap.

As the results should be interpreted with care, the exact numbers should be seen as indicative for the actual magnitudes. In particular, the observed firm-level capital intensity is quite volatile in the second period. This does not affect labour productivity, but does affect the MFP calculations, although its pattern seems plausible. In addition, the results pertain to the manufacturing sector only, and firms with at least 20 employees. The conclusions do not necessarily carry over to other sectors or the full population of manufacturing firms. However, while these firms constitute about 10% of the number of firms in manufacturing, they cover around 85% of total employment in manufacturing.

Despite these caveats, the results clearly point into the direction of a widening productivity distribution. Another issue raised in this report is that there are different ways to describe the changes in dispersion. The message from our results is that while the existing evidence has focussed on relative changes in dispersion ratios, these figures suggest changes that may come across as rather moderate. By contrast, the corresponding changes in the gaps, as also presented in this report, convey a more urgent matter. While both metrics are correct, the user should therefore bear in mind the interpretation. Nevertheless, regardless of the metric used, our results in this report suggest that there is a structural increase in the productivity differences in Dutch manufacturing.

In terms of further research, we suggest the following:[12]

- It would be interesting to zoom in on the subindustry level. This would allow to see if the widening occurs in all manufacturing activities, or only in specific ones. In addition, this could allow for an analysis of whether the widening in total manufacturing occurs mainly within subindustries, or whether there is also an impact of a shift between these subindustries, especially in the wake of the financial crisis;
- The position of a firm in the productivity distribution could be related to firm-characteristics and decisions such as investment in ICT and outsourcing. These long-term relations could be investigated;
- Moreover, the relation between the productivity widening, and possible increasing differences in firm-level wages could be investigated, for the full period used in this paper;
- The assumption of identical price developments for all firms within a certain industry could be refined. In particular, the ProdCom data from 1993 onwards, allows to disentangle value and volume of firm production by commodity group;

[12] A first attempt at resolving the first three bullets will be carried as part of the Horizon2020 project GrowInPro, and included in a paper scheduled for the GGDC Conference 2021.

- The productivity patterns in other sectors could be investigated from 1993. Data is available for the following sectors: construction, business services, retail trade, wholesale trade, and transport.

References

Andrews, D., Criscuolo C., and Gal P. N. (2016)*, The Best versus the Rest: The Global Productivity Slowdown, Divergence across Firms and the Role of Public Policy*. Paris: OECD.

Autor, D., D. Dorn, L.F. Katz, C. Patterson, and J. Van Reenen (2020), "The Fall of the Labor Share and the Rise of Superstar Firms", *The Quarterly Journal of Economics*, Volume 135, Issue 2, pp. 645–709.

Balk, B.M. and Hoogenboom-Spijker, E. (2003), *The Measurement and Decomposition of Productivity Change: Exercises on the Netherlands' Manufacturing Industry*, Voorburg/Heerlen: CBS, Discussion Paper 03001.

Berlingieri, G., P. Blanchenay, and C. Criscuolo (2017), *The Great Divergence(s)*. Paris: OECD.

CPB (2018a), *Notitie koplopers en volgers: geen divergentie in Nederland*. The Hague: CPB Netherlands Bureau for Economic Policy Analysis.

CPB (2018b), *Frontier firms and followers in the Netherlands: Estimating productivity and identifying the frontier.* The Hague: CPB Netherlands Bureau for Economic Policy Analysis.

Felsö, F., M.-L. Kok en J. Theeuwes (2001), *Marktwerking en productiviteit*, Amsterdam: SEO-rapport nr. 598.

Gu, W., B. Yan and S. Ratté , Long-run Productivity Dispersion in Canadian Manufacturing. *Economic Insights*, 84, 3-7.

Meijerink, G., L. Bettendorf, & H. van Heuvelen (2018). Geen divergentie in productiviteit van koplopers en volgers in Nederland, *Economisch Statistische Berichten*, 103(4765), 411-413.

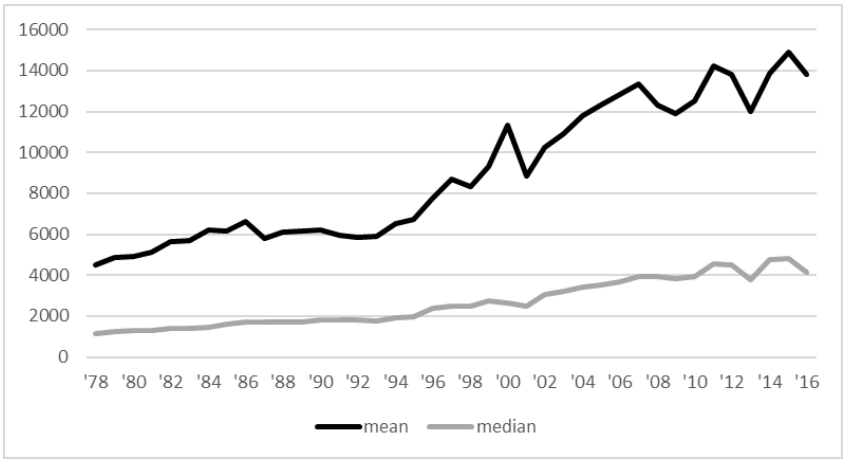
Polder, J.M. (2019), *Comparing productivity patterns across different sources*. The Hague/Heerlen/Bonaire: Statistics Netherlands.

Roelandt, T., M. Akkermans, M. Polder en H. van der Wiel (2019), "De mondiale productiviteitspuzzel voor Nederland", *Economisch Statistische Berichten*, 478-481.

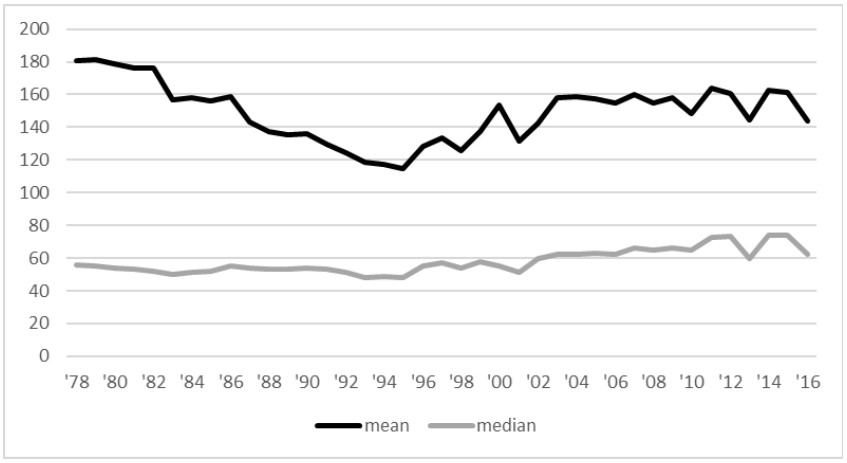
Annex

Figure A1. Mean and median of variables in the analysis.

(a) Nominal value added



(b) Persons employed



(c) Depreciation cost

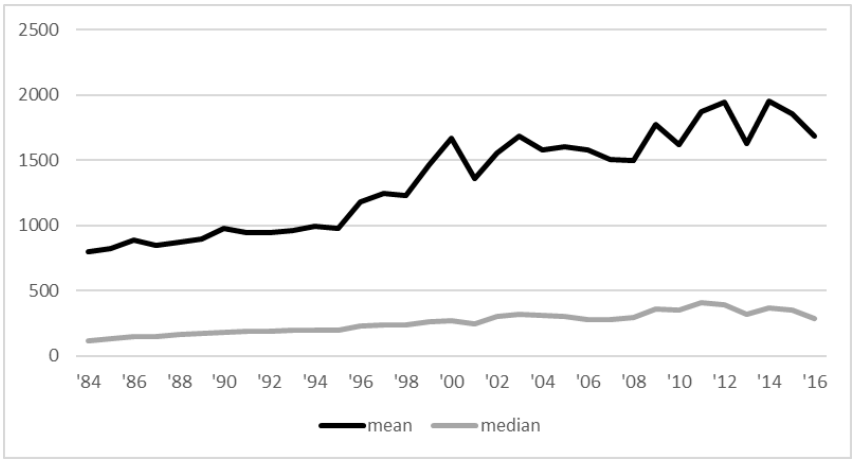


Table A1. Aggregates of manufacturing subindustries used in the analysis.

SBI1993 categories, years before 2009	
10t12	Manufacture of food products, beverages and tobacco products
13t15	Manufacture of textiles, apparel, leather and related products
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
20a21	Manufacture of chemicals and chemical products, pharmaceuticals, medicinal chemical and botanical products
22	Manufacture of rubber and plastics products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment n.e.c.
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment
31a32	Manufacture of furniture and other manufacturing
33	Repair and installation of machinery and equipment
SBI2008 categories, years before 2009	
15a16	Manufacture of food products, beverages and tobacco products
17t19	Manufacture of textiles, apparel, leather and related products
21	Manufacture of pulp, paper and paper products
22	Publishing, printing and reproduction of recorded media
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastic products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except machinery and equipment
29	Manufacture of machinery and equipment n.e.c.
30t33	Manufacture of machinery and equipment
34a35	Manufacture of transport equipment
20a26a36a37	Other manufacturing

Table A2. Percentage change in labour productivity dispersion ratios based on full-time equivalents.

	top-median		median-bottom		top-bottom	
	%	(av.)	%	(av.)	%	(av.)
2002-2016	7,8	(0,5)	10,5	(0,5)	18,4	(1,0)
2002-2005	2,5	(0,8)	4,0	(0,9)	5,5	(1,8)
2006-2008	2,4	(1,2)	2,6	(0,0)	6,5	(1,2)
2010-2016	5,2	(0,8)	4,5	(0,4)	8,4	(1,2)