

Using Publicly Available Financial Data to Measure
Production Depth in the Automobile Industry

By

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ABSTRACT

Often companies must make the decision whether or not to manufacture a part on their own or to outsource the manufacturing of that part to a supplier. The results of these “make-or-buy” decisions have impacts on that company’s manufacturing competencies and strategies moving forward [1]. They also compound over time to define that company’s production depth. A company’s production depth is defined as the ratio of value-adding content that a company creates itself [2]. While the impact of “make-or-buy” decisions have clear implications on a company’s long-term strategies, the relationship between a company’s production depth and its profitability has not yet been studied as there is not a defined way to measure production depth from a company’s publicly available financial data.

This study examines two different methods of estimating production depth using publicly available financial data. The first method uses the ratio of raw and in-progress materials versus finished goods in a company’s inventories to represent the company’s production depth. The second method for estimating production depth is the ratio of the difference between the company’s manufacturing cost and total trade purchases to its total cost of manufacturing.

This study used the first method to evaluate different automotive companies’ production depth in 2018. This study also examines BMW’s production depth using both methods. The first method of measuring production depth is advantageous because all public automotive companies published the data on their inventories necessary to make the calculation. The second method is advantageous because it takes into account costs with manufacturing outside of just material costs. While there were no statistically significant relationships found between this study’s production depth estimates and profitability, applying these two methods two automotive

companies allowed us to gain insight into estimating production depth using publicly available financial data.

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1 Introduction and Background

1.1 Motivation

Current literature on outsourcing focuses heavily on its impact on the cost and the quality of the product [1]. This means that the impacts that outsourcing has on a company’s ability to make manufacturing innovations or integrate changes to their product are not fully understood. Sources conflict on how outsourcing affects market share, product quality, and product recalls [1, 3, 4, 5, 6]. Studying production depth helps us understand the complex relationships that result when decisions are made on whether or not to outsource.

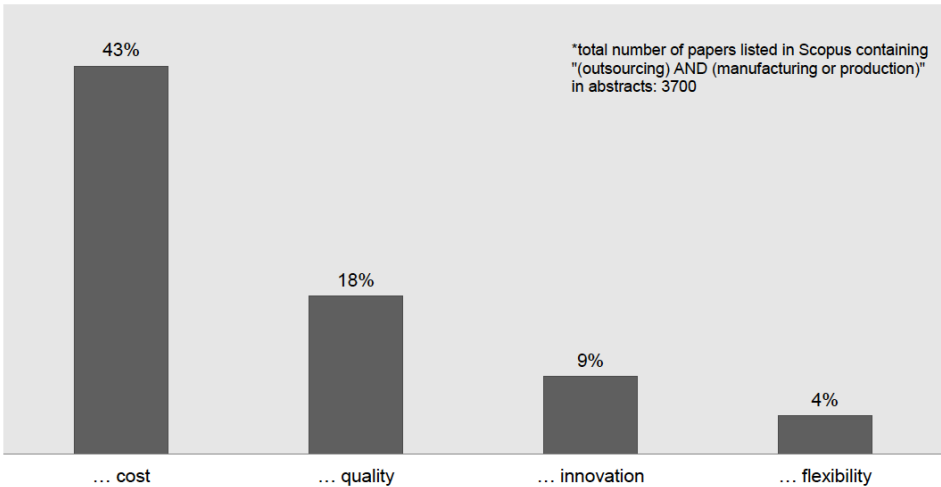


Figure 1-1: Percentage* of Papers Dealing with Outsourcing of Manufacturing and Overview of issues discussed in literature regarding outsourcing [1]

The current issue when attempting to study production depth in a company or an industry is the lack of a standardized method of measuring production depth. Consulting companies such as Oliver Wyman and financial institutions such as Deutsche Bundesbank have done studies involving production depth. [7, 8]. However, Oliver Wyman’s work has not been published and so their methodology is not accessible to be evaluated by academics [7]. Deutsche Bundesbank’s work is published and available to the public; however, they study production depth in the context of German industries and not specific companies [8]. Also, companies such as BMW have self-reported their production depth in interviews, but these methods may not be replicable to study without availability to a lot of classified company data [9, 10, 11].

This study aims to measure production depth in a company using publicly available data. The creation of a replicable method for estimating production depth that is available for academics to evaluate and study can help us gain a better understanding of the relationship between outsourcing and its consequences.

1.2 Defining Production Depth

Production depth is defined as the ratio of value-adding content created by a company itself [1, 2]. This ratio “quantifies in-house production as a share of total output and reflects the degree of vertical integration in production processes” [8]. While production depth can be evaluated as a quality within an industry or a country, for the purposes of this study we look at production depth as a quality of a company.

2 Methodology

2.1 Estimating Production Depth Using Inventories Data

2.1.1 Calculating Production Depth as a Ratio of Materials in Inventory

Inventories are a commonly reported asset in a company’s balance sheet. Inventories of materials are recorded as “the lower of average acquisition cost and net realizable value” [12]. Commonly inventories are then further broken down into three main categories of raw materials, work-in-progress, and finished goods or goods for resale.

Since production depth is the ratio of value-adding content that is created by the company itself, we can estimate that ratio by the company’s investment in its materials. In this model, raw materials and work-in-progress materials are counted as materials that will be manufactured by the company, so they fall into the category of value-adding content created by the company itself. The finished goods and goods for resale are assumed to be purchased from a supplier, so they do not fall into this category. Therefore, production depth was calculated as the sum of raw materials and work in progress inventories divided by the total inventories.

2.1.2 Assumptions in the Model

The key assumptions in this model are that the company’s inventories are representative of their production process in general. The other key assumption is that the finished goods and goods for resale are considered to be goods from suppliers, and other inclusions in this category are negligible. We know that vehicles in buy-back contracts are included in the finished goods category [12], but in the model we assume them to be negligible. Given this, we do expect estimations of production depth from this model to be lower than the actual production depth.

The advantages of this model are its accessibility. Nearly every car manufacturer reports their inventories within the bounds of those three main categories, meaning this model can be applied to all of these manufacturers. Also, no additional data is necessary to make this estimation of production depth, so one can make the estimation using only the financial data provided in publicly available financial reports.

2.2 Estimating Production Depth Using Trade Payables

2.2.1 Calculating Production Depth Using the Ratio of Trade Purchases to Manufacturing Costs

The second method this study used to estimate production depth was using a ratio of net trade purchases over manufacturing costs. Trade purchases in this instance represents purchases made to suppliers of parts. Total trade purchases were calculated as Trade Payables, as reported in the liabilities section of the Balance Sheet, multiplied by the company's Accounts Payable Turnover rate. The Accounts Payable Turnover rate is defined as the ratio of total supply purchases to the average accounts payable [13]. Because trade purchases represents purchases made to suppliers, the investment the company makes in creating value by itself is equal to the difference between total manufacturing costs and net trade purchases. Production depth can then be represented with the following ratios where production depth is PD , net trade purchases are NTP , manufacturing cost is MC , trade payables is TP , and accounts payable turnover is APT .

$$PD \cong 1 - \frac{NTP}{MC} = 1 - \frac{TP * APT}{MC} \quad (1)$$

2.2.2 Calculating Accounts Payable Turnover

Accounts Payable Turnover Rate is being used in this study to find the Net Trade Purchases. Because Accounts Payable Turnover Rate is not a figure that is published in a company's financial reports we must make our own estimations of it. This study used knowledge of an initial Production Depth value to back solve for Accounts Payable Turnover Rate. In 2007, BMW reported that it had a production depth of 25-30% [9]. This starting point allowed us to find BMW's Accounts Payable Turnover Rate using by back solving using the following equation:

$$APT = \frac{NTP}{(BAP+EAP)/2} = \frac{MC*(1-PD)}{TP} \quad (2)$$

Once Accounts Payable Turnover has been calculated for BMW in the year 2007, we are able to use that to calculate Accounts Payable Turnover in following years using a trailing average. The equation used to do this for the year n is as follows.

$$APT_n = \frac{NTP_{n-1}}{(TP_n+TP_{n-1})/2} \quad (3)$$

2.2.3 Assumptions in the Model

The major assumption in this model is that the trailing average allows us to gain an accurate perception of the Accounts Payable Turnover. The key data that is necessary to perform this estimation is the availability of the Trade Payables data as well as the availability of a production depth figure or another figure that allows us to solve for our first Accounts Payable Turnover. Unlike the inventory data necessary to execute the first model, not every automotive manufacturer published a Trade Payables figure in their yearly financial reports. The requirement

of the Trade Payables data and a Production Depth figure to make an initial estimate of Accounts Payable Turnover makes this method less accessible than the first. Because this model is based off of subtracting Net Trade Purchases from the total Manufacturing Cost, the advantage of this model is that it takes into account more than just the materials costs that are the basis of the first model.

3 Results

3.1 Production Depth of Car Manufacturers Based on Inventories in 2018

Using the inventories data provided in companies' annual reports, production depth was estimated for nine different automotive manufacturers in the year 2018. The results of these estimations are shown in Table 3-1. The net profitability of these companies was also measured as the ratio of the company's net income to its total sales.

Table 3-1: Production Depth Estimations and Net Profitability for Automotive Manufacturers in 2018*

Company	Raw Materials (mil. of \$)	Work-in-Progress (mil. of \$)	Finished Goods (mil. of \$)	Production Depth Estimate (%)	Net Profitability (%)
BMW	1347	1305	11439	18.8	5.9
GM	0	4274	5542	43.5	6.0
Ford	0	4536	6684	40.4	2.3
Toyota	638	479	986	45.6	8.5
Honda	4907	655	8759	38.8	7.3
Subaru	399	492	1903	31.9	6.5
Volkswagen	5986	4733	32997	24.5	5.2
Fiat Chrysler	146	4086	7318	36.6	3.0
Hyundai	1876	751	5362	32.9	1.7

Production depth estimates using inventories data and net profitability of nine automotive manufacturers in 2018. *Data from each company's respective annual reports in FY 2018. All inventories data is shown in millions of USD. The following conversion rates were used to standardize currency: 1.08 Euros = 0.0094 Yen = 0.00084 Korean Won = 1 USD.

To examine these relationship between these figures further, net profitability was then plotted against production depth. In the figure we can see a general trend of net profitability increasing as production depth increases. Linear fits to this trend were unable to show a statistically significant correlation. Quadratic fits to this trend produce statistically significant results.

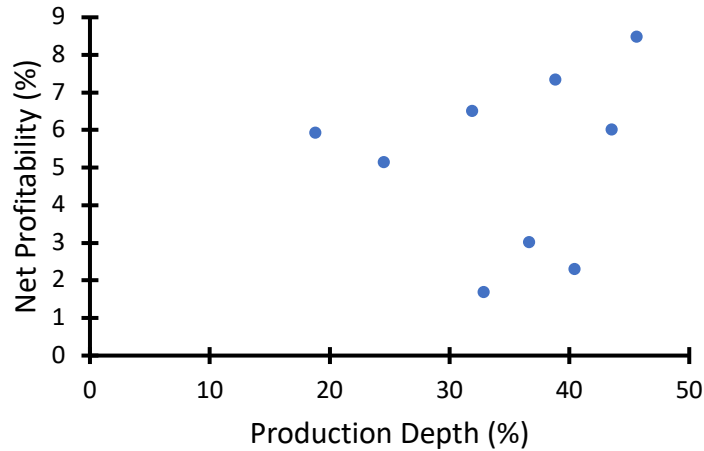


Figure 3-1: Net profitability plotted versus production depth. Linear and quadratic fits yielded no statistically significant results.

3.2 Production Depth of BMW Based on Inventories (2007-2018)

To further explore the inventories method of estimating production depth, this study evaluated the production depth of BMW from the years 2007 to 2018. Table 3-2 shows the results of the production depth calculations, along with the inventories data used to calculate it.

Table 3-2: BMW’s Estimated Production Depth Using Inventories Data From 2007-2018*

Year	(mil. of Euros) Raw Materials	(mil. of Euros) Work In Progress	(mil. of Euros) Finished Goods	(mil. of Euros) Total Inventory	(%) Production Depth	(%) Net Profit Margin
2007	632	871	5846	7349	20.5	5.4
2008	596	803	5891	7290	19.2	0.5
2009	536	542	5477	6555	16.4	0.0**
2010	663	683	6420	7766	17.3	4.8
2011	704	908	8026	9638	16.7	7.9
2012	786	827	8112	9725	16.6	6.7
2013	843	850	7892	9585	17.7	6.2
2014	918	944	9227	11089	16.8	6.0
2015	1004	1098	8969	11071	19.0	6.0
2016	1000	1157	9684	11841	18.2	6.3
2017	1146	1125	10436	12707	17.9	6.0
2018	1247	1208	10592	13047	18.8	5.9

*Data from BMW’s Annual Reports from FY 2007-2018.

**Net loss marked as 0.0% Net Profit Margin

The accuracy of these production depth estimates is hard to say as there is only one figure that is known for BMW’s production depth. We know that in 2007, BMW reported they have a production depth between 25 and 30% [9]. Our estimates put BMW’s production depth in 2007

at 20.5% which is roughly 80% of the expected production depth. A possible explanation for the low estimate of the production depth is inflation of the Finished Goods inventories due to the inclusion of cars on buy-back contracts.

In Figure 3-2, we see the production depth and net profit margin from Table 3-2 plotted against each other. No quadratic or linear fits were found to be statistically significant.

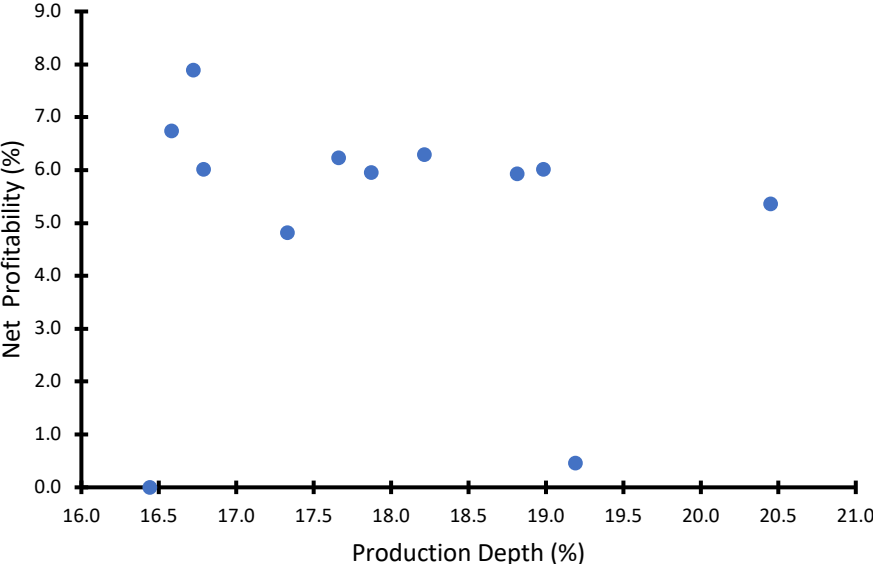


Figure 3-2: Net Profitability versus production depth measured using inventories data in BMW from 2007 to 2018.

3.3 Production Depth of BMW Based on Trade Payables (2007-2018)

Production depth was also measured in BMW using the Trade Payables data. Knowing that BMW’s production depth was 25-30% in 2007 allowed us to solve for an Accounts Payable Turnover rate of 6 in 2007 [9]. For 2008-2018 a trailing average was used to solve for the Accounts Payable Turnover rate. Table 3-3 below summarizes the production depth data using this method and net profitability for BMW during this time period. Figure 3-3 plots net profitability versus the production depth measured using trade payables. No statistically significant linear or quadratic fits were found.

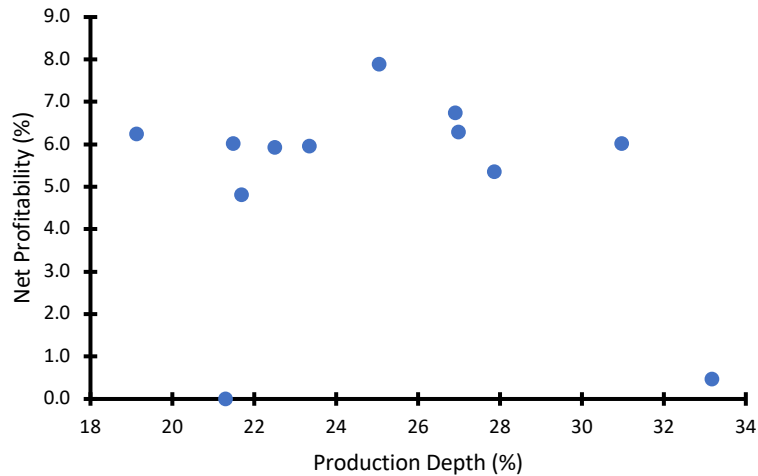


Figure 3-3: Net Profitability versus production depth from trade payables data in BMW from 2007 to 2018.

Table 3-3: BMW's Estimated Production Depth Using Trade Payables from 2007 to 2018*

Year	(mil. of Euros) Manufacturing Cost	(mil. of Euros) Trade Payables	(mil. of Euros) Accounts Payable Turnover	(mil. of Euros) Net Trade Purchases	- Production Depth	(mil. of Euros) Net Profit (Automobiles)	(mil. of Euros) Revenues (Automobiles)	(%) Net Profit Margin	(%) Gross Profit Margin
2007	29536	3551	6	21306	27.9	2963	55,263	5.4	19.8
2008	26727	2562	6.97	17859	33.2	226	48782	0.5	10.8
2009	24930	3122	6.28	19618	21.3	-439	43737	0.0**	9.4
2010	29173	4351	5.25	22845	21.7	2607	54137	4.8	17.4
2011	33594	5340	4.71	25176	25.1	4991	63229	7.9	20.7
2012	37648	6433	4.28	27514	26.9	4737	70208	6.7	19.5
2013	36572	7475	3.96	29575	19.1	4408	70629	6.2	18.2
2014	38253	7709	3.90	30031	21.5	4521	75173	6.0	18.6
2015	43685	7773	3.88	30155	31.0	5147	85536	6.0	17.7
2016	43175	8512	3.70	31523	27.0	5441	86424	6.3	17.9
2017	43877	9731	3.46	33630	23.4	5276	88581	6.0	18.4
2018	43262	9669	3.47	33522	22.5	5091	85846	5.9	16.2

*Data from BMW's Annual Reports from FY 2007-2018.

**Net loss marked as 0.0% Net Profit Margin

The average difference in the production depth measured using trade payables and the production depth measured using inventories data was 7.1% with upper and lower 95% confidence bounds of 14.4% and -0.1% respectively. The standard deviation on the differences of the production depth estimates was 3.7%. A t-test between the two sets of production depth estimates show that we can be 99% confident that there is a statistically significant difference between the two data sets. This means that the differences in the data set cannot be explained by variance, and there are fundamental differences in the two methods used in this study which result in different production depth estimates.

4 Conclusion

While our results did not indicate statistically significant relationships between profitability and production depth, this study does provide some insights into measuring production depth using publicly available financial data. Two methods of measuring production depth were explored in this study. The first method uses the ratio of raw and in-progress materials versus finished goods in a company's inventories to represent the company's production depth. The second method for estimating production depth is the ratio of the difference between the company's manufacturing cost and total trade purchases to its total cost of manufacturing.

While the first method of estimating production depth can be performed with only a company's inventories data, the second method requires the company to publish trade payables data as well as a figure that allows us to solve for accounts payable turnover. These figures are both necessary in the second method to calculate total trade costs, so that they can be compared to manufacturing costs.

The strengths of the first method are its accessibility as most major car manufacturers published inventories data in 2018. The strengths of the second method is that it encompasses all investments into manufacturing costs and not just material costs. This view provides a more accurate representation of the investment made by a company into creating value in its products. The other strength of the second method is that it is not affected by cars on buy-back contracts, while the first method is.

While we know with 99% confidence that the two methods of measuring production depth produce different results, we do not have enough data points to say which of the two methods is more accurate. The only known production depth of BMW is that it was 25-30% in 2007 [9]. Because we use this figure to obtain accounts payable turnover in 2007, we know that our production depth estimate using trade payables falls within this range. While the estimation using inventories data falls below this range. Because the estimation using inventories data falls below our only known figure and is consistently lower than our estimation using trade payables by an average of 7.1%, this suggests that the estimate using trade payables data is more accurate. However, more known figures of production depth would be necessary to assess this.

Moving forward, I believe both these methods should be explored more to help estimate production depth. While these methods do contain assumptions that may affect their accuracy, they still provide a step forward in understanding the trends of how much companies are investing in creating value in their products versus outsourcing. Once a method of measuring production depth using publicly available financial data can be standardized, we can use it to better understand the complex relations between decisions to manufacture versus outsource parts and how it affects a company's profitability and long-term strategy.

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