Universidade Vigo

FACULTADE DE CIENCIAS EMPRESARIAIS E TURISMO DE OURENSE

Bachelor Thesis

Direct Material Cost Efficiency Analysis

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An Assessment of Valuation Methods at Mitsubishi Fuso Truck and Bus Corporation

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Academic Year:	2018 - 2019

Abstract

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Topic

Direct Material Cost Efficiency Analysis: An Assessment of Valuation Methods at Mitsubishi Fuso Truck and Bus Corporation

Summary

In material intensive industries such as the automotive sector, the analysis of direct material costs is of special importance for internal cost control and profitability assessment. This paper is a practice-related comparison of three direct material cost efficiency valuation methods implemented within the business environment of a truck and bus manufacturer. These valuation methods are an actual-based valuation method, a frozen-volume-based valuation method, and the direct material price variance. This analysis investigates into the differences between the valuation methods and assesses its information accuracy and usability from a company perspective.

This assessment is based on internal company information gathered by the application of the interview method and the study of provided training documents and reports. Value stream analysis was applied to identify the origin of each valuation method's database. The presented valuation methods were assessed based on their computational logic and their application in the given business environment.

In regard to their calculation logic, all valuation methods were found to have potential for calculating commercial material cost efficiencies. However, considering the business environment, several technical limitations were identified and rendered the direct material price variance inapplicable. Current business reports showed that despite calculation inaccuracies, the actual-based approach delivers the best cost approximation.

The conducted assessment revealed that the proper calculation of direct material cost efficiencies not only depends on a selected valuation method as such, but also on technical aspects like data consolidation and process efficiency in the respective business environment.

Keywords:

Material cost management, material cost efficiency, valuation methods, price effects, actual costing system, direct material price variance, static budgeting

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List of Abbreviations

ACT	Actual (data type)
AP	Actual Price
AVoB	Annual Volume of Buy
COM	Commercial (price effect)
COGS	Cost of Goods Sold
DICV	Daimler India Commercial Vehicles (entity)
DTA	Daimler Trucks Asia (organizational unit)
EBIT	Earnings before Interest and Taxes
EPU	Expected Parts Usage
FIFO	First in, first out (inventory valuation method)
FX	Foreign Exchange Rate (price effect)
FY	Full Year (period)
IPS	International Procurement Services
JPY	Japanese Yen (currency)
LCM	Life Cycle Management (price effect)
LIFO	Last in, first out (inventory valuation method)
MFTBC	Mitsubishi Fuso Truck and Bus Corporation (entity)
MTD	Month-To-Date (period)
MP	Mercedes-Benz Cars Procurement (organizational unit)
PCRC	Price Change Reason Code
QTY	Quantity
RM	Raw Material (price effect)
SG&A	Selling, General and Administrative Expenses
TECH	Technical (price effect)
TP	Transfer Price (price effect)
TP	Trucks Procurement (organizational unit)
YE	Year End (period)
YTD	Year-To-Date (period)

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1. Introduction

In material cost controlling of Mitsubishi Fuso Truck and Bus Corporation (MFTBC), currently two different valuation methods are in use to calculate the actual monetary effect of direct material cost changes related to the performance of procurement activities. This information is valuable for the management of procurement activities since it gives insights into which materials costs increase or decrease. Due to its explanatory power of how the company can manage its material costs efficiently, these procurement-related price changes are internally defined as commercial material cost efficiencies. Provided that a price change is only related to procurement activities, these price changes can be calculated as the product of a purchasing quantity component and the difference between two material prices from different points in time.

$$Material\ Price\ Efficiency = Quantities\ Purchased * (\ Price_t - Price_{t-1})$$

For many years, material cost controlling has not been able to systematically track cost efficiencies by themselves. Procurement controlling has control over a cost management tool used as a record to keep track of material cost savings that have been achieved by buyers. As its main feature, this tool uses a measure of planned quantities, estimating the expected volume of parts that is assumed to be purchased over a period of one year. For this reason, this method will subsequently be referred to as the “Frozen Volume Approach”. It uses actual prices to determine the extent of regarded cost changes. This valuation approach is helpful for planning purposes, but when it comes to determining actual cost figures, it is criticized for providing only an approximation to the actual costs incurred.

For that reason, material cost controlling has implemented an alternative valuation approach. It is meant to give a better representation of material cost efficiencies and to help gauging the material cost effect of those efficiencies on the company’s EBIT results. This alternative approach not only uses actual prices but also actual quantities purchased, extracted from purchasing records every month. It is based on a report created with the application Microsoft Power BI, but its implementation is not yet fully completed. Since the use of actual information is its main characterizing feature, this valuation method is referred to as “Actual Approach”.

The existence and deployment of two different valuation approaches beg the question as to which approach can ultimately add greater value for the company and whether there is an alternative approach that could be applied and may even be better.

One alternative that could be suitable is the use of the Direct Material Price Variance. In standard costing, this price variance determines the pure price effect of cost changes by multiplying quantities purchased with the difference of an actual price and a standard price of a material. For the calculation of production related material costs, Direct Material Price Variances are already used at MFTBC. But why is this method not used to calculate material price efficiencies?

1.1 Purpose of this Paper

The purpose of this paper shall be the comparison and evaluation of the Frozen Volume Approach, the Actual Approach, and the Direct Material Price Variance, which all aim to determine the price effect of cost changes. The assessment shall be made from a controlling perspective and shall focus on two main aspects:

- Calculation logic: All methods use the same formula, but are based on different sets of data. For the comparison of how the application of different datasets influences the usability of the approaches, it is required to isolate the calculation logic from their organizational context.
- Application at MFTBC: Applied at MFTBC, both methods come with different organizational premises. In order to make a realistic assertion of how the three methods bring or could add value to the company, their organizational context and their manner of implementation must be considered.

Taking into consideration these different perspectives, the valuation methods shall be analyzed by focusing on the following key questions:

- What is the basis of the datasets used in the valuation methods?
- How does the organizational context at MFTBC influence the application of the valuation approaches?
- Which calculation method achieves a higher level of accuracy and usability?
- Can the Actual Approach be used as an indication of how material cost changes affect the income of the company?
- Is there a need for improvement and what are possible measures?

1.2 Method & Approach

All internal company information presented in this paper has been gathered by the application of the interview method and the study of provided training documents and reports. Interviews conducted will be referred to as personal communication. For data protection purposes, all specific organizational or system-related terminology has been changed to abstract wording.

As an introduction into the context of material costs and the analysis of material cost efficiencies, this paper begins with the explanation of basic concepts and terminology that serve as a basis for the following examination.

Then, the organizational context will be explained. Insights will be given into how MFTBC is connected to the corporate landscape of Daimler AG and how the application of the regarded valuation methods is connected to the organizational structure at MFTBC. In order to convey an understanding of what kind of costs material cost efficiencies actually relate to, the material cost scope and related price effects will be introduced.

The analysis itself starts with an introduction of the three regarded valuation methods. By examining how the valuation methods are implemented in the MFTBC organization, it shall be found out what kind of data sets are used and how the organizational context may oppose limitations to the usability of the valuation methods. For this purpose, the used data sets shall be examined by applying a value stream analysis. Thus, the used data shall be traced back to its origin, which could provide insights into if and how the price and quantity information used in the valuation methods is suitable.

For an overall comparison of the regarded valuation methods, the features of the methods will be examined on the basis of different examples and sample calculations. Further assessment shall clarify to which extent the valuation methods can be used to explain material cost related changes of income at MFTBC.

Lastly, potential solution approaches shall be deducted and critically reviewed.

In the end, this paper shall give a clear picture of how the valuation methods differ from each other. By comparing their calculation logic per se and also with respect to their organizational context, it shall be concluded which valuation method can potentially and actually add more value to MFTBC. Key aspects of this assessment shall be the usability and information accuracy of these valuation methods for actual cost reporting.

2. The Theoretical Context

This first section shall give an introduction into the topic of material costs and efficiencies from a theoretical standpoint.

2.1 Material Cost Management

In manufacturing, a company's business concept is based on the conversion of materials into a product designed for sale. Production is not possible without materials that are needed as inputs in the conversion process. Therefore, it is imperative for a business to stay in control of the flow of materials. From an accounting perspective information on materials is key to maintain control. Material Cost Management is referred to as the entirety of measures applied to quantify the flow and consumption of materials on a monetary basis (Wagner & Enzler, 2005, p. 8). The following explanations are limited to materials used in the production of manufacturing businesses.

2.1.1 The Nature of Materials

According to Osborn (Osborn, 1980, p. 5), the term material is commonly accepted as of supplies that are procured for and used in the conversion process of a manufacturing business. Following his material classification approaches, materials can be classified based on their use, their identity upon purchase and their status when kept in storage (Osborn, 1980, pp. 4-16).

Material Usage Classification:

During the process of production, materials can be used in many ways. For accounting purposes, it is important to identify to which extent materials are used for the production of a product:

- Direct Materials are referred to as materials consumed during production and can be directly associated with a final product. Usually, direct materials can be found on the bill of materials of a product. For example, components such as screws, tires, and engine are considered as direct materials in the assembly process of a car.
- Indirect Materials cannot be directly traced back to a product. This applies to consumable materials such as engine oil, or chemical cleaning agents used to keep machines running; to process materials like cold oil used in the hardening process of metals; or maintenance materials that are used to maintain a plant and its equipment.

Material Identity Classification:

Materials that are procured for production can have all kinds of shapes and qualities. These characteristics determine the usability of a material. By their usability raw materials, partly manufactured parts and bought-out finished items can be distinguished.

- Raw materials can be understood as two different types of manufacturing inputs. In extractive industries, materials are produced in a sense of “raw” as in virgin materials. This refers to commodities such as e.g. crude oil, steel, and coal. But in a general production context, raw materials are considered supplies that still require to be further worked upon in order to retrieve a finished product ready for sale.
- Partly manufactured parts are items in a state of partial completion. Partly manufactured parts are usually considered as inputs in production when a business decides not to manufacture an entire part by itself, e.g. due to lack of skills or capacity.
- Bought-out finished items summarize all sourced parts that require no further work. Materials of this type can be used directly for the assembly of products or can be resold as merchandise. Some businesses undertake no manufacture themselves. For assembly focused businesses, bought-out finished items can make up for up to nearly 100% of the overall material consumption (Wannenwetch, 2014, p. 17).

Storage Status Classification:

Throughout production activities, materials go through different kinds of conversion processes and may change their appearance, form and value. For the accounting of materials, it is therefore essential to keep record of these changes and to evaluate their value within inventory. Consequently, it can be analyzed how investments into supplies finally have transformed into sellable outputs, or waste. The status materials can assume throughout the production process can be described as stocks, work in progress (WIP) or finished goods:

- Stocks are materials that are sourced externally. Materials are usually stocked upon their delivery in warehouses until they will be processed in production.
- Work in progress relates to materials that have already been modified in at least one production step and thus record increases in value.
- Finished goods are parts that have passed all production steps and don’t need further processing (Osborn, 1980, p. 9).

For the distinction of materials, it is essential to keep track of material flow throughout the value chain. The classification by production state is an essential element of the

monetary valuation of materials in storage and finished goods that have already been sold. This information is required as a company needs to set up its income statement at the end of a financial period (Chapman, et al., 2016, p. 237).

2.1.2 Material Costs and its Components

Costs incurred by materials used in production are divided by their quality to be assigned to a cost object. In manufacturing, this is usually a product. Material costs that can directly and exclusively be traced back to a single cost object are considered as direct material costs. The main criterion for the identification of direct material costs is the physical identification of a material assigned to a cost center. In the example of automobiles, individual parts used in the assembly of a car can directly be assigned to a product by their count. Material costs that cannot be directly assigned to a cost center, such as grease used on machines in production, are considered as indirect material costs (Drury, 2018, p. 23).

Conducting analyses on material cost requires a complete understanding of what material costs are composed of and what they refer to. According to Lanen et al. (2011, p. 38), costs can generally be described as a sacrifice of resources. Following their definition, costs are characterized by quantification of resource consumption and a valuation base, expressed as a price. For the determination of materials costs in production, it is necessary to quantify the material consumption. Monetary evaluation of the material consumption happens by the use of a related price. Material costs therefore consist of a price and a quantity component:

$$material\ costs = quantities\ consumed * price\ per\ unit$$

There are different ways to determine the price and quantity component of material. For the comparison of material costs, one must be aware of how material consumption and price have been determined. The following explanations elaborate on how material consumption can be quantified and which kind of price information can be used to evaluate the overall cost of material consumption.

The Determination of Material Consumption

For the purpose of determining material consumption, Joos (2014, pp. 129-132) distinguishes two main key figures: Actual consumption and Planned consumption:

Actual consumption of production materials is understood as an exact representation of the quantity of materials consumed. A typical method to gauge actual consumption is the

inventory-based counting method. For this method, beginning inventory and closing inventory are determined by inventory counts at the beginning and at the end of a period. Material influx is determined on the basis of delivery notes or goods receipt notes. With this information the material consumption can be determined as follows:

$$Consumption = Beginning\ Inventory + \sum Goods\ Receipt\ - Closing\ Inventory$$

The high degree of accuracy of this method comes with a high effort of its deployment since inventory counts are resource intensive.

Planned consumption on the other hand is a technical approximation of the actual material consumption. It is usually applied in the industrial sector to enable the processing and planning of high material consumption rates. For this purpose, material consumption is estimated retroactively by using bills of material and current sales plans. Material consumption is calculated by multiplying the planned consumption of an individual material item with the total number of finished units produced:

$$Consumption = planned\ consumption\ per\ product * quantities\ produced$$

This method is simple in its logic but requires a thorough consideration in the production set-up in order to be properly implemented. Its main drawback is that the material consumption is based on planned values and therefore doesn't consider changes in market demand or unexpected consumption through for instance scrap.

Prices as a Valuation Basis

Prices are used as a monetary component for the determination of material costs. The accuracy of material costs is highly dependent on the chosen evaluation base. Depending on the context of material consumption, different prices may be applied. Figure 1 shows an overview of possible valuation bases.

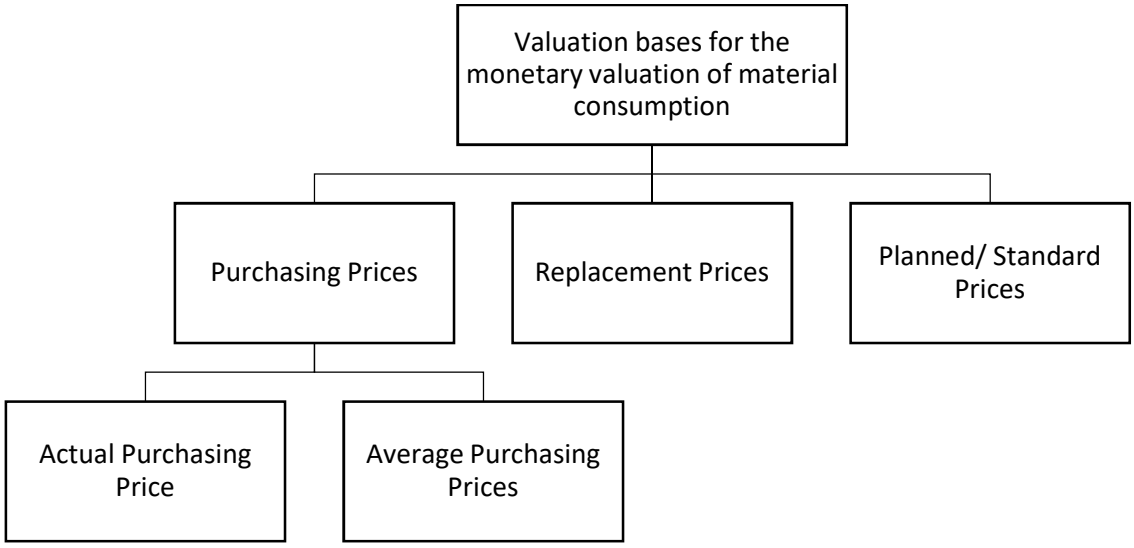

Figure 1: Overview of price information as valuation bases; taken modified from Joos (2014)

Purchasing prices summarize a number of valuation approaches that are based on invoice prices, relating to a particular purchase order of a material. The purchasing price is the result of an invoice price, diminished by value-added taxes and discounts and increased by possible extra expenses related to shipping, such as customs and insurances. The result is the so-called material base price.

The use of actual purchasing prices requires a direct relation between the purchased volume of a material and its price. If materials in stock have been purchased at different prices, it is required to identify which items have been bought at which price. For this purpose, inventory valuation methods are deployed. Common methods are:

- First in, first out (FIFO): This method assumes that materials that first enter inventory will also be withdrawn first. Materials that have been bought at different prices are therefore put into sequence and can be distinguished at their count.
- Last in, last out (LIFO): In this method materials on stock are sequenced by assuming that materials that entered an inventory last, will be withdrawn first.

The application of actual purchasing prices becomes difficult, once the variety of materials in stock and its corresponding purchasing prices and purchasing quantities increase. In material-intensive businesses with series production, average purchasing prices are used. One example is the weighted-average price, which determines the price average under consideration of ordered volumes. Average purchasing prices are considered as good approximations for the valuation of material consumption.

Replacement prices can be an alternative to purchasing prices when materials are concerned with very volatile prices. Assuming that after the purchase of a material its price increased significantly, it can be problematic to use the historical purchasing price for the purpose of product price calculation. In this case, the materials in stock were undervalued and products could be sold as too cheap. Replacement prices can be for example current market prices at the day of consumption, or the expected purchasing price of a material on the day of reordering.

In connection with the use of a standard costing system, material consumption can also be evaluated by standard prices. Standard or planned prices are usually based on historical actual prices and consider price changes expected in the future. Standard prices are useful as they allow an organization to plan ahead of time on the basis of approximated values. For controlling, they can be helpful to determine volume-based cost developments, since they remove price-related cost variations. But as planned prices, they can only provide an approximation to actual costs (Joos, 2014, pp. 133-137).

2.1.3 Income Effects of Direct Material Costs

For the assessment of a company's financial performance, production-related material costs are periodically determined as a key component of the income statement. For this purpose, direct material costs and indirect material costs are reviewed separately. Production-related indirect material costs are considered as a part of the production overheads and must be considered by applying a suited cost assignment approach since they cannot be directly identified with the final product.Direct material costs, on the other hand, can directly be assigned to a final product. This means that regardless of the applied cost accumulation system, as variable production costs they are fully incorporated in the calculation of the company's income. The application of both, the variable cost system and the absorption cost system is not problematic (Drury, 2018, pp. 154,155).

But when it comes to the value flow of direct material costs, it must be considered that costs depend on the selected cost perspective. Direct material costs can be accounted for as purchasing costs, production costs or cost of goods sold (COGS). These different cost perspectives differ from each other by referring to different value streams that may provide different results within a financial period. While purchasing costs are solely determined on the basis of purchasing volume within a given period, production costs and COGS depend on production volumes and sales volumes respectively. This

differentiation is crucial since the income of a company is calculated on the basis of COGS (Lanen, et al., 2011, p. 46).

For the consideration of how many materials are finally incorporated within the COGS at which price, inventory valuation methods are applied. Following the previously introduced storage status classification of materials, all materials in stock, regardless of yet unprocessed materials, work in progress or finished goods, are recorded and evaluated based on their usage throughout the production process. The choice of the inventory valuation method is not only important for logistical reasons, but it is also important for the valuation of material at a suitable price. In particular, when using actual prices, production costs or COGS can vary significantly from purchasing costs, when processed material has been purchased at different prices (Lanen, et al., 2011, pp. 47,48).

2.2 The Concept of Material Cost Efficiency

Following the definition of a generic dictionary such as dictionary.com, efficiency is understood as “the state or quality of being (…) able to accomplish something with the least waste of time and effort” (Dictionary.com LCC, 2019). In common speech, efficiency is often used interchangeably with the term effectiveness. According to the Oxford English Dictionary, both terms can even be considered as synonyms (Oxford University Press, 2010). But in economics, including the business-related context of this paper, it is imperative to not only differentiate between these terms but also to specify what type of efficiency one is referring to.

Efficiency differs from effectiveness as efficiency describes the status of how inputs of a system convert into related outputs. This can be substantialized by quantitative measures such as time, matter or costs. Effectiveness, on the other hand, describes the degree to which an objective in terms of a desired set of outputs has been achieved (Oxford University Press, 2009). In further explanations of this paper, only the term efficiency with regard to direct material costs will be of relevance.

The analysis of material costs can give valuable insights into how efficient materials - needed in production - are handled and processed along the supply chain. In order to understand how questionable material costs evolve, costs need to be traced back to its constituting elements - price and volume (Joos, 2014, p. 129). In standard costing, variance analysis is used to identify how price and volume influence the overall development of direct material costs.

The Direct Material Price Variance analyses the purchasing price of materials and indicates how changed purchasing prices may affect the total cost of a direct material. From a procurement perspective, this information helps to understand how well procurement performs in the negotiation process with suppliers to obtain favorable material prices. In a broader sense, this metric quantifies how efficient buyers have been in optimizing material prices in favor of the organization (Drury, 2018, p. 444).

This metric is calculated on the basis of a standard costing system. An exact representation of incurred costs requires to apply an actual costing system. The term cost efficiency shall be understood as the material cost portion that explains how efficient the purchasing department manages to influence material prices favorably (Drury, 2018, p. 438).

3. Context of Analysis

The following section shall give an overview of the corporate context of this paper. It displays concisely what kind of business the chosen controlling topic is related to and how it is interwoven with and within the corporate structure of the Daimler Group. To understand the subject of the regarded valuation methods, the material cost scope and the related price effects that are the basis of commercial direct material cost efficiency analysis will be introduced.

3.1 Corporative and Organizational Context

The Daimler Group, hereinafter referred to as “Daimler”, is a multinational automotive corporation headquartered in Stuttgart and is one of the biggest producers of passenger cars and commercial vehicles. Being listed on the stock exchanges in Frankfurt and Stuttgart, in 2018 Daimler achieved a revenue of approximately 167 billion Euros by selling around 3.4 million vehicles and having staffed nearly 300,000 employees.

Daimler sells vehicles and services in nearly all the countries of the world and has production facilities in Europe, North and South America, Asia, and Africa. It operates in five business units, such as Mercedes-Benz Cars, Daimler Trucks, Mercedes-Benz Vans, Daimler Buses, and Daimler Financial Services. Daimler Trucks, the second biggest business unit, offers commercial vehicles under the name of Mercedes-Benz, but also other brands - tailored to the needs and characteristics of regional target markets. This includes the brands Freightliner and Western Star, destined for the North American markets, FUSO for East-Asia and Bharat Benz for the Indian Market (Daimler AG, 2018).

The focus of this paper shall lie on the organizational unit Daimler Trucks Asia (DTA) and the corresponding financial function. DTA is a subunit of the business unit Daimler Trucks. DTA focuses on the trucks business in Asia and it encompasses the Daimler subsidiaries Mitsubishi Fuso Bus and Truck Corporation (MFTBC) and Daimler India Commercial Vehicles (DICV), headquartered in Kawasaki (Japan) and Oragadam (Chennai, India) respectively. These entities are charged with the development, production and sale of the brands FUSO and Bharat Benz, offering both in their product portfolio, trucks and buses. While DICV is a wholly-owned subsidiary of the Daimler Group, MFTBC is still partially owned by the Mitsubishi Group (Daimler AG, 2019).

Changing from an entity view to a functional view on Daimler's organizational structure, the financial function of Trucks Asia provides comprehensive financial insights on the truck and bus business throughout the Asian target markets. This paper’s analysis

originates in the subunit material cost controlling. The team of material cost controlling mainly deals with the tracking, planning, and reporting of material costs. Apart from providing intelligence on material costs, special responsibilities are implemented to consider the impact of transfer prices for the flow of materials, modules, and products within the Daimler Group. Contrary to the material cost scope of this paper, which is elaborated upon subsequently, Material Cost Controlling in general accounts for all parts that relate to business activities of MFTBC (Personal Communication, 2019).

3.2 Material Cost Scope

For the understanding of how the two currently prevailing valuation methods for material cost price efficiencies are applied at MFTBC, it is imperative to not just understand the organizational context, but also what the valuation methods actually refer to. It must be clearly defined which kind of material costs an analysis entails.

The material cost scope used in this paper is referred to as “Core Scope” and encompasses materials that are directly related to production activities of MFTBC. Its main characteristic is that it originates from a procurement perspective.

The procurement-based perspective differs significantly from other common views, such as the product-based view and company level view. While the product view includes all materials that are needed for the production of a regarded product, the company view considers all parts that relate to a specific legal entity. As illustrated in Figure 2, the main differences of these three views can be explained by taking into consideration from which kind of supplier the materials are being sourced, how the materials are used, what kind of cost types are involved in the calculation of the overall material costs and which organizational unit has been responsible for the purchase of the materials.

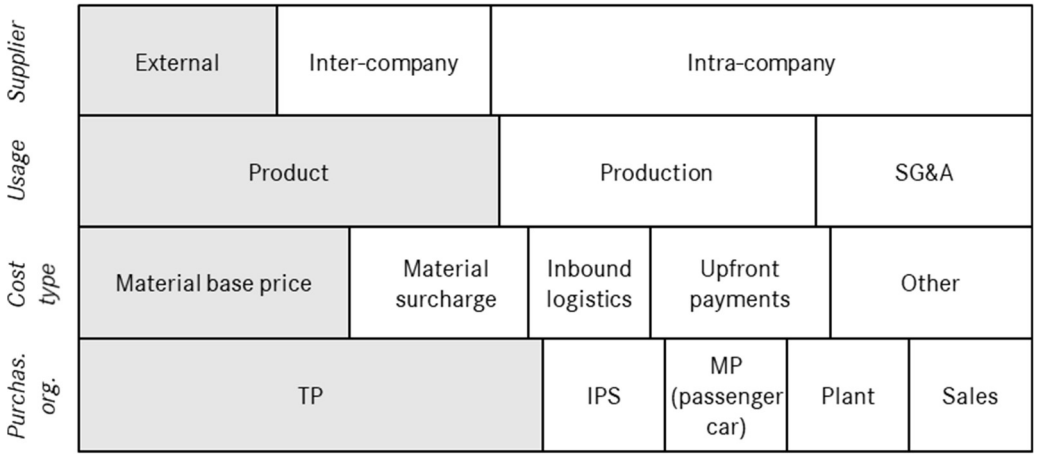

Figure 2: Material cost scope – Procurement entity view (Daimler Intranet D, 2019)

While the product-based view and the company view entail parts that are sourced by all supplier types, the Core Scope only focuses on external, third-party suppliers, since MFTBC's procurement can only be held accountable for those parts, whose prices it can actively influence. This logic is crucial for the application of the price efficiency valuation methods because the results and insights of the evaluation methods can only be used for decision making if they actually represent the performance of procurement activities - including all relevant parts they can account for.

Materials considered within the Core Scope are exclusively direct materials. Only materials that can directly be associated with a product are accounted for by material price efficiency. This excludes all other indirect materials that are otherwise used in production, as for example machine oil, or all other materials that can be considered as selling, general and administrative expenses (SG&A).

Material costs can be comprised of different purchase-related cost types. Next to the material base price, which includes all basic costs that are concerned with the nature of a material, additional costs that come with purchasing and shipping conditions can be applicable. For the Core Scope, only the base price of a material is relevant.

The responsible purchasing unit for this scope is the global procurement department for trucks and buses (TP). As a buying entity, this unit solely focuses on the sourcing of production materials. This differs from the product view and company view, which entail also other buying entities, procuring direct and indirect materials (Daimler Intranet D, 2019).

3.3 Price Effects

After clarifying what kinds of material are to be considered in the evaluation methods, it remains to be specified what kind of price effects the evaluation methods shall account for. Talking about cost efficiencies requires a more detailed examination of purchasing prices and the reasons for their change.

For further analyses on purchasing prices of sourced materials, the Daimler Group has established a group-wide classification system of reasons, why prices may change during the course of a year. These reasons are classified into approximately 100 so-called "Price Change Reasons Codes" (PCRC), hereinafter referred to as PCRCs, and are maintained in Daimler's global procurement system. The system's database comprises information on nearly all existing production materials within the Daimler Group. Relevant part information such as prices and price changes are maintained by

the responsible buyer of each material. Whenever price changes occur, the respective buyer is required to approve the new prices and to select the appropriate PCRC to indicate the reason for the change. In order to be able to monitor price change reasons on the basis of PCRCs, price change reasons are categorized into distinctive categories by which price change reasons can be related to responsible departments. The group-wide implementation of the global procurement system enables Daimler to have an aligned global standard for the classification of PCRC categories.

For the purpose of analyzing the Core Scope from a material cost controlling perspective, the PCRC categories illustrated in Figure 3 are the most commonly used. The waterfall chart shows how the combination of different price effects have an influence on the overall price change of a material in a given period.

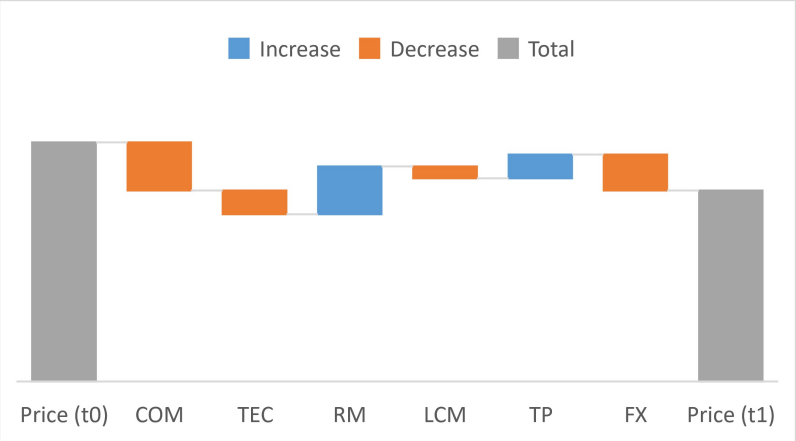

Figure 3: Price effect classification for Core Scope

- Commercial price effects (COM) are directly related to procurement activities and reflect their performance to negotiate favorable prices on behalf of MFTBC.
- Technical price effects (TECH) occur due to engineering changes that have been made on products, components or single parts to decrease material costs.
- Raw material (RM) is considered as an external price effect that cannot be directly influenced by procurement but relies on the commodity exchange.
- Life Cycle Management (LCM) related effects are based on special changes made on material in series production, because of for instance safety reasons, quality reasons, or customer requests.
- Transfer price effects (TP) are subject to transfer price-related price changes for material that is procured within the Daimler Group. Transfer prices are based on group regulations and cannot be influenced by procurement.

- Foreign exchange rate effects (FX) apply to material that is processed within different monetary areas. Exchange rates cannot be influenced by procurement.

For the calculation of commercial material cost efficiencies, only the commercial price effect is applicable since only for this price effect, buyers have the power to negotiate prices. Typical reasons in this context are the conclusion of long-term agreements, the change of purchasing volumes or the continuation of recognizing cost savings created by tooling investments made with suppliers after the amortization time has ended. This is why for the scope of this paper, the regarded evaluation methods are exclusively limited to price effects related to commercially-induced price changes (Personal Communication, 2019).

4. The Valuation Methods – Background, Value Stream & Limitations

After having clarified the context of this paper's analysis, this section introduces the selected valuation methods that shall be subject to the comparison of material price efficiency valuation approaches. Starting with the Frozen Volume Approach first, the background and initial situation of price efficiency calculations at MFTBC shall be illuminated. Consecutively, the Actual Approach and the Direct Material Price Variance will be introduced as alternative approaches. By considering the context of why and how the different valuation methods have been introduced at MFTBC and where the applied data is coming from, key differences of these approaches shall be made clear.

4.1 Frozen Volume Approach

The Frozen Volume approach and its underlying concept and system can be seen as the starting point of a systematic efficiency tracking of material costs in Daimler Trucks. The approach uses an IT solution that will be subsequently referred to as "efficiency tracking system" and serves as a planning and reporting tool for buyers and engineers to document and report commercial and technical results on third-party material. The Frozen Volume Approach is part of a broader material cost steering initiative that has been rolled out some years ago by the global procurement department in Daimler Trucks (Daimler Intranet A, 2017).

The efficiency tracking system is designed to serve as a common database between procurement and other organizational units to provide more transparency for procurement activities and to facilitate decision making. With increased levels of transparency, important indications can be given as to if procurement targets and cost targets can be fulfilled. It provides its users with extensive forecast capabilities and enables procurement to do operational planning throughout the entire year. Its reports help commodity head and lead buyers to obtain valuable information on local purchasing activities.

As a management instrument, the efficiency tracking system is particularly used to track and control commercial and technical related material cost saving potentials. While buyers maintain realized commercial material price changes in the global procurement system only once a new contract has been signed and implemented, the tracking of price efficiencies in the efficiency tracking system already starts earlier. In the latter, buyers start tracking saving potentials as soon as new price negotiations with suppliers are about to start. In order to bring more transparency to the savings potential that may

evolve during negotiations with suppliers, a special savings implementation logic serves as a cornerstone of the efficiency tracking system.

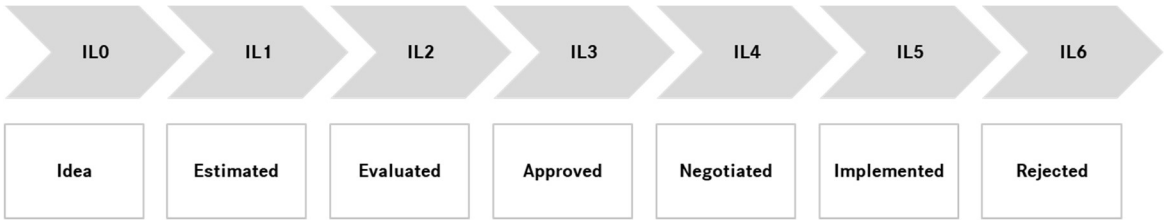

Figure 4: Efficiency tracking system - Implementation logic of saving potentials

As it can be seen in Figure 4, the efficiency implementation logic considers seven possible statuses. Once the idea of price renegotiations has been set, a measure is created in the efficiency tracking system and is assigned the status IL0. Along the course of negotiations, the status changes of the measures are continuously adapted based on the progress that has been achieved. Usually, until price negotiations either end with a newly signed contract (IL4) or end, because they have been unsuccessful (IL6), savings are estimated (IL1), properly evaluated (IL2) and approved by all parties (IL3) in consecutive steps. Once a new contract has been signed, the last step until the negotiated price changes are transferred into the global procurement system is for them to be implemented (IL5). Savings are understood as implemented, as soon as the first financial impact has been recorded.

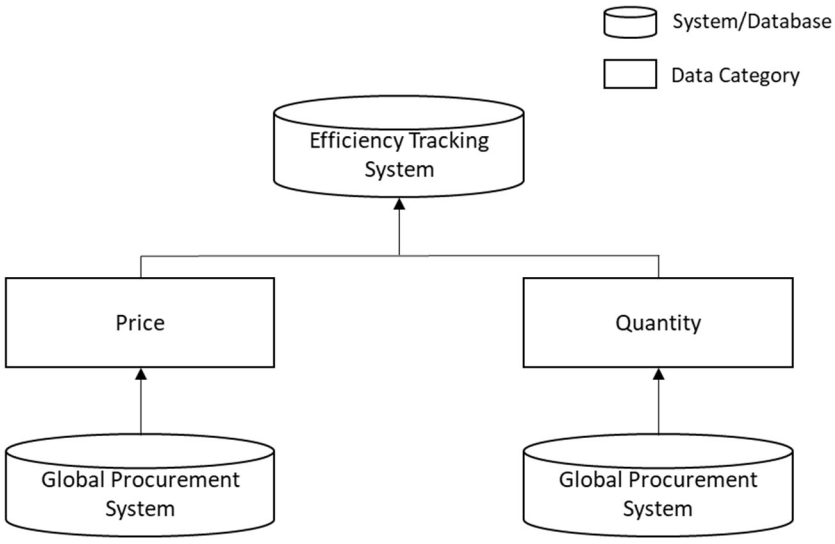

Figure 5: Frozen Volume Approach – Data flow

After the implementation phase, realized savings/ materials price efficiencies are tracked based on information that is then extracted via an interface with the global procurement

system. As the value stream of the Frozen Volume Approach, illustrated in Figure 5, shows, the global procurement system not only keeps record of prices but also of a planned volume figure for every material that is listed (Daimler Intranet B, 2017).

The price component and its data flow:

When it comes to material prices, the global procurement system is considered as the most reliable source for actual material purchasing prices in Daimler. All price information is based on official contracts that Daimler entities entertain with other supplying entities. As the global procurement system is implemented as a central IT solution within the entire Daimler Group, it serves as a single source of truth. Prices listed in the system are therefore also accepted as valid by all Daimler entities.

All price information that the efficiency tracking system extracts from the global procurement system is updated on a daily basis. Along with all prices and price changes that are recorded, price change reasons in the form of PCRCs are also transmitted. Like this, the efficiency tracking system can explain price changes even beyond its initial tracking of commercial price change reasons (Personal Communication, 2019).

The quantity component and its data flow:

The quantity component of the Frozen Volume Approach is determined by so-called expected parts usage (EPU). Expected parts usage is a planned purchase volume that describes the number of units expected to be bought for one material throughout the course of one year. EPU is determined on the basis of an extensive annual planning process that lasts from July until November and requires the cooperation of several functional units (see Figure 6).

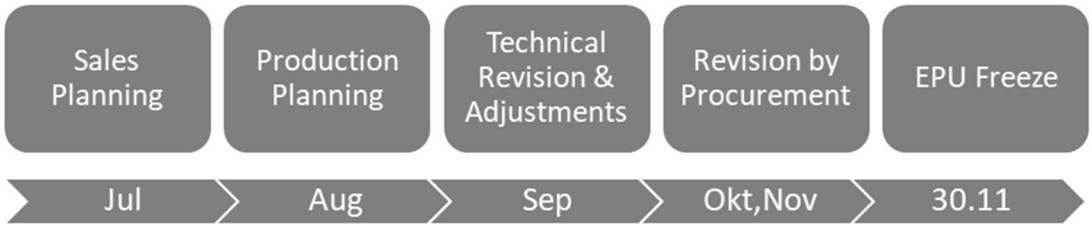

Figure 6: Annual EPU planning process

Beginning in July, the EPU planning process starts with sales forecasts that are prepared by the sales department. On the basis of historical sales and a set of premises that reflect possible influencing factors such as anticipated changes in demand, upcoming legal requirements or changes in product lines, the expected demand for all truck and bus

models is estimated and consolidated in a sales plan. The total amount of expected volume per material is determined under consideration of the bill of materials of every planned model and its first sales forecast.

This information is then passed along to the production department which is charged with establishing a production plan for the following production period. The production planning helps to assess if the estimated potential sales can actually be accomplished. Planned sales may deviate from production capabilities, because for instance the production capacity may not be high enough to meet current demand. Until September, sales and production work closely together to align planning data and solve special planning requirements. As a result, a first draft of EPUs is established at the end of August. During September, the EPU run through several technical revision phases until they are submitted to Procurement at the end of the month.

In a final phase, buyers are tasked to align the planned EPUs with current sourcing capabilities. It must be ensured that the needed material quantities can be procured. Buyers therefore get in touch with contracted suppliers to make sure that they can meet the material demand of the previously established production plan. After a last approval from procurement side, the EPU planning phase ends on 30th November of a year. This is the internal deadline for adjustments. Afterwards, EPU information is not updated anymore. (Daimler Intranet E, 2017).

In the Frozen Volume Approach, price information and expected parts usage are finally merged to calculate the commercial direct material cost efficiency. Provided that a price change is solely based on commercial price change reasons, the commercial direct material cost efficiency is calculated as the product of the expected parts usage (EPU) for a given period and the price difference between two actual purchasing prices in different points of time (Daimler Intranet B, 2017).

$$Price\ Efficiency = EPU * (ACT\ Purchasing\ Price_t - ACT\ Purchasing\ Price_{t-1})$$

Coming from the perspective of operational planning, the Frozen Volume Approach and its consideration of EPU as planned purchasing volume is considered as very valuable since it supports planning activities with substantial information on future purchasing costs and potential cost savings. Allowing purchase planning on parts level, the Frozen Volume Approach ultimately enables the procurement management to develop strategies that are based on substantial data.

But when it comes to assessing the actual monetary effect of commercial direct material cost efficiencies, the results from the Frozen Volume Approach should be critically reviewed. The use of EPU as planned purchasing quantities that are only determined once in a year is not suitable to calculate actual costs. During the planning process of EPUs, future purchasing volume can only be assumed by applying premises. The fluctuation of market demand is a good example of an external factor that cannot be exactly predicted. There may be changes in for instance customer preference, state shifts in the overall economy or even natural catastrophes that can have unforeseen effects on the demand of products (Mankiw, 2017, p. 67). Furthermore, in order to calculate efficiencies within the year, the annual EPU need to be adapted to the regarded period. In the efficiency tracking system, EPU is only broken down to a monthly level. Although price information is updated on a daily basis, this is why the efficiency tracking system calculates efficiencies on a monthly basis only. This may cause an overestimation of actual material costs.

4.2 Actual Approach

The Frozen Volume Approach as a valuation method to determine material price efficiencies comes with a significant flaw. By using an annual-based planned purchasing volume, its results can only serve as an approximation to the cost reality at MFTBC, as opposed to giving an actual picture of how costs evolve. Material cost controlling, tasked with monitoring and reporting of material costs, has long struggled to properly explain actual cost changes that are related to direct material price efficiencies.

In 2018, a task force was established to find a viable solution for this problem. The starting point for this project has been the Frozen Volume Approach. Knowing about the problems that come with the use of EPUs, alternatives needed to be found. The actual purchasing prices that the Frozen Volume Approach uses were generally considered as acceptable. But the quantity component of the calculation should change. The idea was to use an actual figure of quantities bought. Like this, calculated cost changes were expected to also represent fluctuation in purchase volume that so far has completely been ignored by the application of annual fixed EPU.

But unlike the Frozen Volume Approach, there was no established process for the appropriate calculation of actual cost efficiencies that could have been used. Therefore, suitable software needed to be chosen and means to access the desired data needed to be identified.

At first, attempts have been made to use Microsoft Excel as a tool to aggregate different kinds of sample data, and to convert them into reports. But connecting big datasets an advanced level of automation became a growing issue. At one side, the sheer amount of data required to cover the entire material cost scope was too big. The processing of computations was very time consuming and made quick analyses impossible. At another side, the complexity of required connections between the different data is significant. The implementation of required connections and formulas turned out to be complicated since a lot of manual work was necessary.

Considering the difficulties of this approach and the experienced proneness to errors, it was decided to use Microsoft Power BI instead. Its advanced functionalities to process high amounts of data helped to create reports for all materials of the Core Scope. Until today, a customized set of reports created in Power BI is used to determine commercial direct material cost efficiencies.

As it was to be discovered along the implementation process, one of the biggest problems that came with the setup of a reliable price efficiency report was data consolidation. A deeper analysis in the IT architecture of MFTBC revealed that data needed to be extracted from a set of many different local systems with a high level of data fragmentation. The data used in today's Power BI tool comes from a set of different sources. Figure 7 illustrates the flow of price and quantity data that is behind the valuation method.

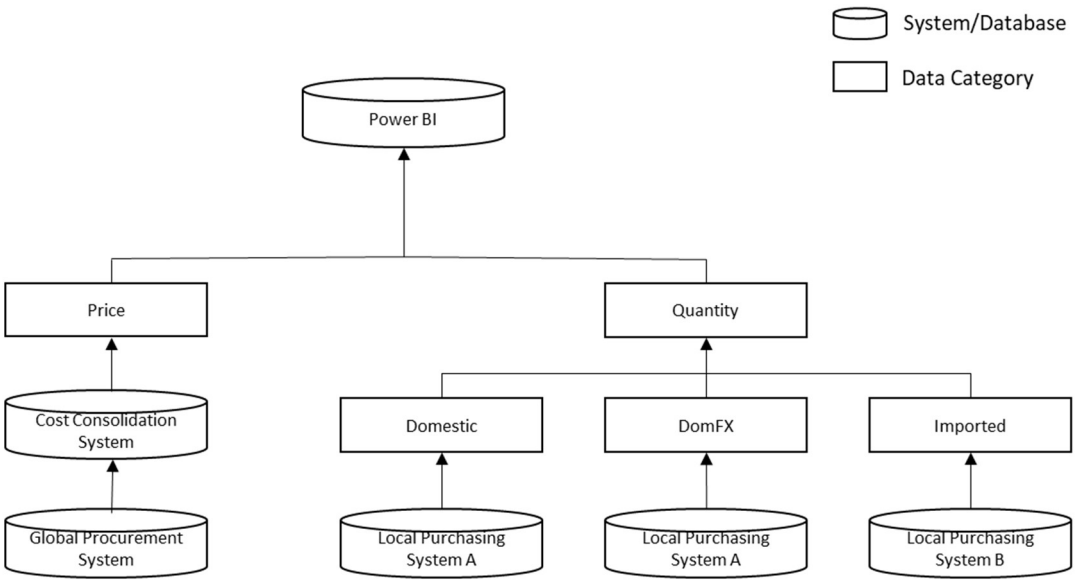

Figure 7: Actual Approach - Data flow

The price component and its data flow:

The main source for the price information is Daimler's global procurement system. As in the Frozen Volume Approach, the contractual base price of a material that has been agreed upon with a supplier is used as a price component of the actual price efficiency. But since the calculation of price efficiencies also requires a distinction of price change reasons, complementary information needs to be extracted.

So far, it is not possible to directly link Microsoft Power BI with the global purchasing system. Alternatively, a special IT solution for material cost controlling is used to extract the desired data from it. This material cost consolidation system is the leading material and product controlling system of Daimler Trucks. Having many interfaces to other local and global Daimler systems, it has been set up to serve as a central database for information on production material.

For the extraction of data in the material cost consolidation system, it is necessary to predefine a number of settings that shall be the basis for reports that can later be downloaded on a regular basis. In this case, it is necessary to determine a list of parts for which the price and price change reason information shall be provided. Usually, bills of material are uploaded into the material cost consolidation system to retrieve information for all parts that a product is comprised of. But since the selected material cost scope entails several products that do not only contain numerous individual parts but also have many parts in common, a modified part list has been created. This part list is the basis for all price information that the material cost consolidation system extracts from the global procurement system.

Inside the material cost consolidation system, necessary prices and price change reasons are not only retrieved from the global procurement system but also directly calculated on part level. The resulting price changes per part and per price change reason are therefore directly available. But in order to have the same classification of price change reason codes by category as in the global procurement system, the regarded material cost report must be separately defined in the material cost consolidation system.

In order to transfer the price information to Power BI, every month a report must be downloaded from the cost consolidation system. This is usually done after the third workday of a month since price information from the global procurement system is

updated in the cost consolidation system only once a month, every second workday of a month. The download then is uploaded into Power BI.

The quantity component and its data flow:

The quantity information that is used in the calculation of the actual direct material price efficiency has different origins. This is due to the fact that orders for material purchases of Core Scope parts are managed by different local purchasing systems.

Three categories of material can be distinguished. There is material that is bought in the domestic market and there is material that is sourced from international markets. In the case of domestically sourced materials, one distinguishes materials further by the currency they are paid in. Material paid in the local currency JPY is considered as “domestic” material, while material paid in another currency than JPY is considered as “domestic fx” – material, affected by foreign exchange rates. This distinction is done to pay particular attention to material costs based on foreign exchange rates.

Domestically sourced material is ordered with a local purchasing system. This system is a transaction processing system that is mainly used to process purchase orders and to record information that is pertinent to the order processing. The quantity information that is used for the calculation is retrieved from the purchasing info record of the system. On the basis of a standardized report, only the quantity information of all goods received is selected. This quantity information is automatically posted as soon as materials enter one of many MFTBC warehousing systems. The report with that information is sent to Material Cost Controlling within the first five workdays of a month and is collected in an Access database. Finally, with the monthly update of the Power BI tool, a selected set of data with month-to-date (MTD) domestic purchase volumes is uploaded into Power BI and converted into a material price efficiency report.

Domestic material that is bought in a foreign currency also comes from the aforementioned local purchasing system but is extracted with a different report. The quantity information is also the volume of materials that are recorded as goods received. Contrary to purely domestic material, the report of this material is loaded into MFTBC’s SAP Business Warehouse. This additional step has to do with the need to translate additional cost information included in the report into the local Japanese currency. The desired quantity information is not further modified and is uploaded into the Power BI tool via an Excel link that bridges the information from the business warehouse into Power BI.

Imported materials are recorded in a separate purchasing system that is exclusively used for processing imported material. The main difference between imported and domestic parts is that imported parts come with a lead time of on average three months. Material orders are also placed directly in the system, but while the quantity information for domestic parts equals the volume of goods received, imported material volume usually relies on dispatch notifications. Upon goods issue by the suppliers, the dispatch notification is sent to MFTBC and is meant to already give an indication of how many goods will arrive. This information is also retrieved by a report that is loaded into the SAP business warehouse, from where the information is also accessed by the use of Excel.

Based on the introduced price and volume components, the actual direct material price efficiency is calculated as the product of the actual purchase volume of a material in the given period of one month and the difference of two actual prices in different points of time (Daimler Intranet G, 2018).

$$Actual\ Direct\ Material\ Price\ Efficiency = ACT\ Purchasing\ Volume * (ACT\ Price_t - ACT\ Price_{t-1})$$

As the Actual Approach uses actual purchase volume information, a first superficial glance may suggest that this approach overperforms against the Frozen Volume Approach with an increased level of information accuracy. Among others, this statement will be examined in the example calculations of the following chapter 5. But special consideration should be given to particular elements of its data flow.

In this method, the calculation of material price efficiency depends heavily on the completeness of the material cost information. Critical elements in the calculation process of actual material price efficiencies are the underlying part list and the reclassification of price change reason codes that are necessary to retrieve a report from the material cost consolidation system. In series production, parts are regularly changed for numerous reasons. A change of series parts means that the defined material cost scope also changes with it. As a consequence, the part list in the material cost consolidation system also needs to be adapted regularly. With regard to the reclassification of PCRCs, once PCRCs in the global procurement system are changed, or new ones are added, the report in the material cost consolidation system must also be adapted. The adjustment of the corresponding part list unfortunately goes along with a significant organizational and technical effort. For that reason, part number changes are not promptly reflected, which leaves the overall process with an increased potential for inaccuracy.

Another limitation is presented by the updating frequency of the price and volume information used in the calculation. Both inputs are updated only once a month. Therefore purchased material is only evaluated with the latest purchasing price that is available in the global purchasing system at the time of the update. This carries the risk that sub periodic price changes are ignored and calculated cost changes could be overestimated.

In the case of imported material, the use of volume information on the basis of dispatch notifications includes the risk of using inaccurate purchase volumes since possible sources of error can be recording errors in the dispatch notification itself, but also shipping delays or loss of shipments. Special consideration should also be given to the lead time of imported parts. A delay of several months from the moment when the dispatch information arrives at MFTBC until the actual goods arrive at its warehouses may cause serious distortions between cost actually incurred and costs recorded.

4.3 Direct Material Price Variance

As part of the variance analysis in a standard costing system, the Direct Material Price Variance serves as an accounting concept that determines the monetary effect of deviations of actual purchasing prices from planned standard prices. The Direct Material Cost Variance is used to identify price effects that are incorporated within direct material related changes in production costs. Reasons associated with this variance are mainly procurement related and entail aspects such as varying order sizes, transportation costs or urgent shipments (Diriba, 2013, p. 169).

At MFTBC, Direct Material Price Variance analysis is conducted by material cost controlling. For the purpose of a monthly material cost reporting, variances are scrutinized bottom-up from part level. This allows a detailed examination of material costs by multiple dimensions such as by product segment, production plant or supplier.

The calculation of Direct Material Price Variances is established as a report function of the local purchasing systems of MFTBC. Figure 8 shows the value stream for this report.

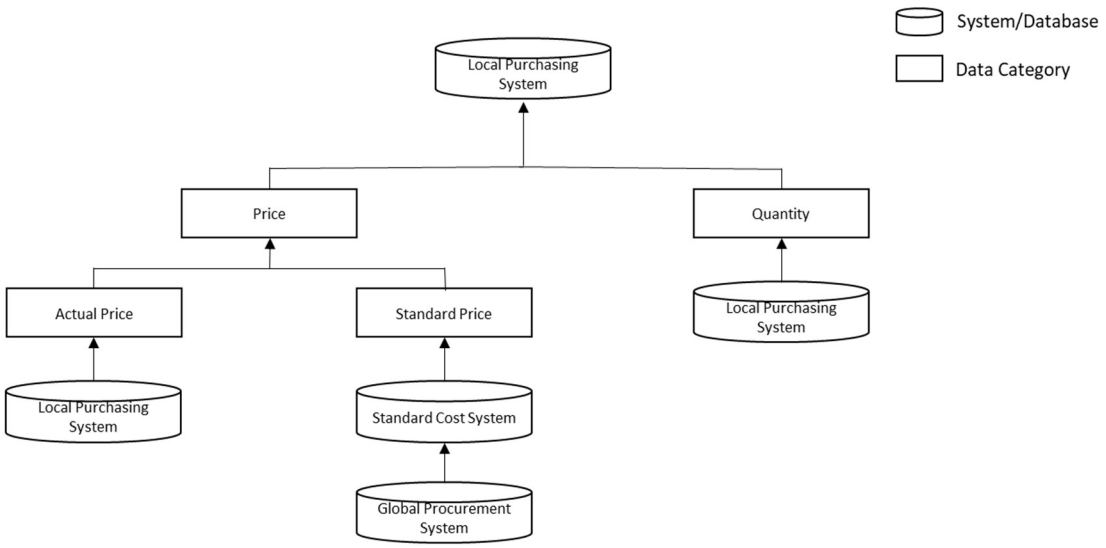

Figure 8: Direct Material Price Variance - Data flow

Actual prices are directly taken from the "accounts payable" ledger maintained in the local purchasing system on a daily basis. Standard prices are provided by the standard cost system of MFTBC. Standard prices are set once a year during a planning process of four months. This process uses actual purchasing prices coming from Daimler's global procurement system, and ends in December. The quantity component is coming from the purchasing system itself. As in the Actual Approach, applied quantities differ depending on domestic or imported material. While domestic material is evaluated with quantities received, imported materials rely on the quantities quoted in the dispatch notification of suppliers. Although there are two local purchasing systems that account separately for domestic and imported material, the value stream and functionality of the variance calculation is identical in both systems (Personal Communication, 2019).

The Direct Material Price Variance is calculated as follows (Diriba, 2013, p. 170):

$$Direct\ Material\ Price\ Variance = (Actual\ Price - Standard\ \ Price) * Actual\ Quantity\ Purchased$$

As a part of today's monthly variance analysis, the price variance could easily be applied to calculate material cost efficiencies. But since its current implementation does not consider PCRCs, special consideration should be given to the calculation of commercial material cost efficiencies for materials with several price effects.

5. Cost Analysis

As already indicated in section 4. The Valuation Methods – Background, Value Stream & Limitations, the presented valuation methods use very distinct sets of data. Since the formulas used in the valuation methods are identical, it becomes even more important to understand which monetary effect the different data sets have on their usability. Therefore, by using a set of selected sample calculations, it shall be examined how the valuation methods differ in calculating commercial material cost efficiencies.

In a first step, the valuation methods will be compared in a neutral context, without taking regard to the special limitations that are given by MFTBC's corporate context. Like this, the valuation methods shall be solely assessed based on their computational concept. Subsequently, special examples shall be introduced, which reflect particular limitations that are subject to the organizational context of MFTBC and the calculation of commercial cost efficiencies. Contrasting the first assessment based on the computational concepts, the valuation methods shall finally be examined based on their usability at MFTBC.

All valuation methods finally determine a monetary figure that is expressed in terms of costs. However, for the steering of a company, it is also required to understand how incurred costs impact the overall income and profitability of a company. In a last step, it shall be examined how direct material cost efficiencies are reflected in the income statement of MFTBC.

The settings of all subsequently illustrated samples calculations are purely fictional. The examples are specifically designed to indicate a particular set of differences between or limitations of the applied valuation methods. For that reason, each example comes with a different example setting, which does not allow results to be compared across examples. The level of detail presented is highly simplified. A truly realistic situation would involve many products and a complex combination of product, process, and system related limitations. For all examples, the annual cost view shall be applied.

5.1 A Comparison of Valuation Principles

In the following examination of Example 1, all valuation methods are applied without taking into account any limitation that the organizational context of MFTBC may present. In a first step, it shall be illustrated how the valuation methods are applied. Since the calculations are similar for all presented materials, only the calculations for one material will be exemplified.

Example 1: Price and Volume Effects

Context: In the last year (2018) Procurement has invested additional effort into renegotiating purchasing prices of production materials with all its suppliers. Beginning from 1st January, all successfully renegotiated prices have come into effect. After the completion of the first annual quarter, the procurement management has tasked material cost controlling to perform a cost analysis on the material cost of product P1. The management wants to know if and how the renegotiations have affected the material cost of P1. For the assembly of P1 the materials M1, M2 and M3 are needed. It shall be assumed that cost changes are exclusively based on commercial price effects.

Data: For this purpose, accounting has gathered all necessary data:

	Validity Period	M1	M2	M3
Prices (per unit)				
AP (YE18)	06/01/2018 - 12/31/2018	€ 18.00	€ 1.10	€ 5.00
AP (19)	01/01/2019 - 12/31/2019	€ 15.00	€ 0.90	€ 5.00
Standard price	01/01/2019 - 12/31/2019	€ 18.50	€ 1.10	€ 4.70
Quantities				
ACT QTY	01/01/2019 - 03/31/2019	40	1000	120
EPU	01/01/2019 - 12/31/2019	180	5000	480

Table 1: Example 1 - Example Data

For the application of the Frozen Volume Approach, actual purchasing prices and the volume of EPU are required. The material cost efficiency shall be calculated for the period of YTD March 2019. This means that the purchasing price valid on 12/31/2018 and the purchasing price that was valid for the duration of the first annual quarter need to be identified. On 12/31/2018 M1 was listed for a price of 18.00€. During the first quarter of 2019, it was purchased for a price of 15.00€. According to the expected part usage of M1, 180 units are expected to be bought over the course of the year. Broken down linearly to the first three months of 2019, it can be deducted that 45 units were expected to be purchased for YTD 2019.

Following the calculation formula introduced in 4.1 Frozen Volume Approach, the deduction of the YE price of M1 in 2018 from its new valid purchasing price in 2019 shows that the unitary purchasing price has decreased by -3.00€. If the purchasing price had not decreased, the material costs for M1 would be 810.00€ (18.00€ * 45 units). But

as a consequence of the price decrease, the total material costs could be decreased by -135.00€ (-3.00€ * 45 units) to 675.00€ (15.00€ * 45 units) for the first quarter of 2019.

The Actual Approach differs from the Frozen Volume Approach by using actual purchasing volume. For M1, the unitary price decrease by 3.00€ is therefore also applicable. But according to the records, the actual purchasing volume for M1 was 40 units. In terms of costs, the material costs for M1 would have been 720.00€ (18.00€ * 40 units), if there had not been a price decrease, which led to commercial cost savings of -120.00€ (-3.00€ * 40). The total material cost for M1 results in 600.00€ (15.00€ * 40) for the first three months of the year.

The application of the Direct Material Price Variance requires information on the value of standard prices, actual prices and the actual purchasing volume. The standard price for M1 has been set at 18.50€. Compared with the actual price of 15.00€ the purchasing price seems to have been successfully decreased by -3.50€. This means that compared to the calculated standard costs of 740.00€ (18.50€ *40) the total actual costs of M1 have decreased by -140.00€ (-3.50€ *40) to 600.00€ (15.00€ *40).

Table 2 gives an overview of the different results that are obtained upon the application of the valuation methods on all materials of P1:

	M1	M2	M3	P1
Frozen Volume Approach				
Total Cost at AP (YE18)	€ 810.00	€ 1,375.00	€ 600.00	€ 2,785.00
Total Cost AP (19)	€ 675.00	€ 1,125.00	€ 600.00	€ 2,400.00
Cost Delta	**€ (135.00)**	**€ (250.00)**	**€ -**	**€ (385.00)**
Actual Approach				
Total Cost at AP (YE18)	€ 720.00	€ 1,100.00	€ 600.00	€ 2,420.00
Total Cost AP (19)	€ 600.00	€ 900.00	€ 600.00	€ 2,100.00
Cost Delta	**€ (120.00)**	**€ (200.00)**	**€ -**	**€ (320.00)**
Price Variance				
Standard cost	€ 740.00	€ 1,100.00	€ 564.00	€ 2,404.00
Cost impact at AP (19)	€ 600.00	€ 900.00	€ 600.00	€ 2,100.00
Cost Delta	**€ (140.00)**	**€ (200.00)**	**€ 36.00**	**€ (304.00)**

Table 2: Example 1 – Overview of calculation results

The results show that regardless of the valuation method, the renegotiation of purchasing prices in 2018 has led to cost savings for P1 in the first quarter of 2019. But this is not the case for all materials. Across the presented materials, the valuation methods generally indicate different cost savings. While for example the Frozen Volume Approach and the Actual Approach indicate no savings for M3, the application of the Direct Material Price Variance led to a cost increase of 36.00€.

These different results can be traced back to price and volume effects that come from different data sets used in the valuation methods.

The Frozen Volume Approach and the Actual Approach are using the same price information. Thus, diverging results should therefore only be explainable by different purchasing volumes. After breaking down the annual EPU for all materials, it can be clearly seen which purchasing volume has been applied by each method:

	Validity Period	M1	M2	M3
ACT QTY	01/01/2019 - 03/31/2019	40	1000	120
EPU YTD Mar19	01/01/2019 - 12/31/2019	45	1250	120

Table 3: Example 1 - Comparison of ACT QTY vs. EPU

For M3, both methods conclude that there are no cost savings since the actual purchasing volume and the EPU for YTD March 2019 are both 120 units. For M1 and M2, on the other hand, these figures differ by 5 units and 1250 units respectively. In these cases, it seems that the future purchasing volume has been overestimated during the planning of the EPU. By multiplying the 5 and 1250 units with its respective prices deviations of 3.00€ and 0.20€, resulting in 15.00€ and 50.00€, it can be confirmed that the difference in cost savings between the Frozen Volume Approach and the Actual Approach only come from a volume effect.

When comparing the Actual Approach with the Direct Material Price Variance, it can be noticed that both methods rely on actual purchasing volume. The differences in material cost savings calculated by both methods should therefore come from the different price information they use. In the case of M2, both methods indicate cost savings of -200.00€. Here, YE18 price and standard price are both 1.10€. But for M1 and M3 on the other hand, YE18 price and standard price vary. M1 has a standard price of 18.50€. The YE18 price is with 18.00€ -0.50€ lower. It seems that in the time between the setting of the standard price and the 12/31/2018 the purchasing price has changed. Multiplying the price difference of -0.50€ with the actual total volume of 40 units, it can be confirmed that the difference of -20.00€ in cost savings between the Actual Approach and the Direct Material Price Variance comes solely from a price effect.

In the comparison of the Frozen Volume Approach and the Direct Material Price Variance, not only different prices but also different purchasing volumes are used. Therefore both, price and volume effects should be applicable. Following the previous conclusion that due to a similar standard price and actual price for M2, the presented gap in material

cost can be explained by a volume effect, the difference between the Frozen Volume Approach and the Direct Material Price Variance of 50.00€ is also caused by a volume effect. For M3 on the other hand, Table 3 shows that the actual purchasing volume is identical with the EPU. Thus, it can be ruled out that the presented difference in savings of 36.00€ comes from a volume effect. But considering that the standard price for M3 with 4.70€ is 0.30€ lower than the actual purchasing price of 5.00€, which has also not changed from 2018 to 2019, a price effect can be assumed. The calculation of 0.30€ multiplied with the purchasing volume of M3 with 120 units confirms the existence of a price effect of 36.00€. It could be surmised that after the setting of the standard price, the actual purchasing price of M3 has increased.

For the assessment as to how the price renegotiations in 2018 have affected the total cost of P1, the results of the Actual Approach should be preferred, since this method only uses actual data. Opposed to planned data such as standard prices or EPU, only actual data can give a realistic representation of the costs that are incurred in business activities. The price renegotiations have therefore led to a total cost saving of -320.00€, divided among M1 and M2 with achieved cost savings of -120.00€ and -200.00€ respectively. The result of the Frozen Volume Approach varies significantly from the actual saving with -385.00€. The Direct Material Price Variance indicates with -304.00€ lower savings than actually achieved.

5.2 Special Limitations at MFTBC

The previous example calculation has shown how the valuation methods are expected to work if no restrictions are posed upon them. Unfortunately, their application at MFTBC comes with a number of crucial limitations that are related to the composition of purchasing prices in real life situations, the implementation of the valuation methods and the organizational context at MFTBC. The following explanations elaborate on how the major limitations affect the usability of the valuation methods.

The distinction of price change reasons

For the determination of the commercial direct material cost efficiency, it is essential to distinguish between different price change reasons, if applicable. As already illustrated in 3.3 Price Effects, apart from the commercial efficiency, many other effects such as technical price effects or raw material effects can be responsible for the development of material costs.

For the Frozen Volume Approach and the Actual Approach, there is no problem to distinguish between different price change reasons. Both methods are connected to the Daimler's global procurement system, which provides all the necessary actual price information. For the Direct Material Price Variance, on the other hand, it is not possible to calculate commercial efficiencies at MFTBC. While actual prices are available, MFTBC's standard cost system does not consider different price change reasons in their planning approach. Standard prices can consequently not be broken down to individual price change reasons.

A plausible explanation for why price change reasons are not tracked in the standard cost system is the effort that would be required to plan price effects on standard prices. Considering that most of the price effects are determined by external factors, it would be very difficult to forecast the development of price effects. Additional costs related to this effort were hardly satisfying, nor would they be justified by their purpose, since there are other alternatives better suited to determine commercial material cost efficiencies.

The subsequently presented limitations assume a higher level of detail. Since the application of the Direct Material Price Variance is not helpful to calculate commercial efficiencies at MFTBC, all further explanations refer only to the Frozen Volume and the Actual Approach.

Part Number Changes

In series production, it happens regularly that used parts or components are changed. Sometimes, production material cannot be provided anymore by its suppliers, or are meant to be procured by a different supplier, because of better price conditions. In all these cases the part number assigned to the materials changes due to an internal policy at MFTBC. For the calculation of commercial material cost efficiencies, this is problematic.

In the case of the Frozen Volume Approach, its entire material cost scope is based on the EPU that is set for each material. Since the EPU for materials is only planned once in a year, the efficiency tracking system only tracks materials based on part numbers that have been existent at the moment of the EPU planning. Therefore, so-called K-measures are implemented to manually adjust the efficiency that would be disregarded if they weren't separately calculated.

For the Actual Approach, part number changes also pose a bottleneck. The material cost scope tracked in the Power BI tool is based on the predefined bill of materials that must

be uploaded into the material cost consolidation system to define the cost scope for the needed material cost report. The adaption of the report is a long process that cannot be done without the support of IT administrators. For that reason, updates are currently conducted only every few months. As a consequence, efficiencies on new part numbers must be calculated manually. But manual tracking of single part numbers requires a lot of effort. In order to calculate efficiencies correctly, it must be identified which predecessor part number belongs to a new part number. Only like this, previously achieved efficiencies can also be considered for the new part number.

Mid-Year Savings

Another problem related to the creation of new part numbers is the consideration of mid-year savings for those materials, which have not just been changed but are completely new. This category of efficiency is tracked apart from other part number change related efficiencies.

In order to determine the full year effect of commercial material cost efficiencies, the Power BI tool for the Actual Approach is programmed to compare the current purchasing price of a material against the purchasing price of that material on 12/31 of the previous year. Once a new part number is created within a year, the historical prices of its predecessor part number are not further maintained. For that reason, there is no YE price for these materials, which make it impossible for the Power BI tool to reflect their efficiency in its reports. Manual bottom-up calculations are required.

In the efficiency tracking system, the calculation of commercial cost efficiencies is programmed differently. Prices can be compared regardless of a valid price in the previous year's end. But since new part numbers are generally not reflected in the efficiency tracking system, efficiencies cannot be calculated. K-measures are currently not available for this type of efficiency. Thus, not even manual adjustment done.

Price changes within a month

The exact determination of material costs with actual prices relies on accurate matching of prices and its corresponding quantity information. Once a material price changes within a month, it must be identified for which volume the prices are applicable. Example 2 shows how in this case commercial efficiencies are ideally determined. Only actual data is used.

Example 2: Price changes within a month

Context: On 4/15/2019 a new purchasing price for material M4 became effective as a consequence of price renegotiations. The price change has no other price change reasons. In May, the commercial cost savings of M4 shall be determined for a monthly report on the cost development in MTD April.

Data: All necessary data was provided by accounting:

	Validity Period	M4
Prices (per unit)		
AP (YE18)	06/01/2018 - 04/14/2019	€ 80.00
AP (YTD April)	04/15/2019 - 12/31/2019	€ 75.00
Quantities		
ACT QTY	04/01/2019 - 04/14/2019	200
ACT QTY	04/14/2019 - 04/30/2019	350

Table 4: Example 2 – Example data

According to the given data in Table 4, the price renegotiations caused the purchasing price of P4 to fall from 80.00€ to 75.00€. To distinguish how many costs have actually been saved by the price decrease, the purchasing volume before and after the price change must be evaluated separately with each particular price. Before the price change, 200 units of M4 have been bought, resulting in material costs of 16,000.00€. After the price change, the purchasing volume increased to 350, which leads to material costs of 26,250.00€. Comparing the total material costs of M4 with 42,250€ with the material costs of 44,000.00€ (80.00€ * 550 units) that would have been incurred if the price changed had not happened, one can conclude that cost savings of -1,750.00€ have been achieved in April.

While the Frozen Volume Approach is principally capable of distinguishing price changes within a month, the Actual Approach is not. In the efficiency tracking system, the EPU can be broken down to only a daily level. Since the only linear breakdown of an annual planned figure doesn't reflect any seasonal changes in demand, it is highly imprecise. Therefore, in daily business, usually, a monthly break-down is applied. The expected purchasing volume is finally evaluated based on daily updated actual purchasing prices. The Power BI tool used to calculate the actual efficiencies is only updated once in a month. Therefore, a matching of different prices within a year with corresponding quantities is not possible.

As a consequence of this problem, an internal agreement has been reached in procurement that price changes are supposed to be approved from the beginning of a month. This means that for commercial efficiencies, the impact of price changes within a month can be neglected. However, for technical efficiencies, which are not considered in the Core Scope, price changes within a month still pose a problem of calculation accuracy. Price changes are also accounted for by cost engineers, who regularly still set prices changes upon their own choosing.

Retroactive Payments

In all previous cases, efficiencies have been obtained from price changes that happened before the actual purchase of materials. The category of retroactive payments is a special case which refers to efficiencies that are realized ex-post. Figure 9 illustrates the context in which this type of efficiencies emerges.

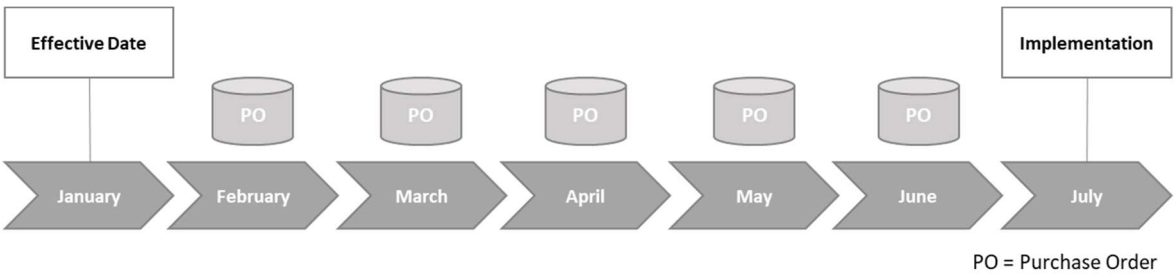

Figure 9: Retroactive payments – Chronological sequence of events

Sometimes it happens that the final implementation of a negotiated price change occurs after its effective date - the date when a price has been agreed upon to become effective. Given that between the time of the effective date and the final approval of prices, purchase orders are made, those purchase orders are invoiced based on prices from before the negotiations. For new prices to be applied, the entire implementation process must be completed. This circumstance leads to the necessity to correct cost savings that should have been made based on a newly negotiated price, by subsequent retroactive payments. Retroactive payments are therefore reimbursements from the supplier to compensate for the price difference of the new and previous price.

In terms of efficiency, this means that the price difference of a material must be quantified with the purchased quantities from all orders that have been made between the effective date and implementation date of regarded prices in order to calculate the efficiency correctly.

Currently, neither the Frozen Volume Approach nor the Actual Approach is suited to calculate efficiencies retrospectively. This is due to missing information on effective dates and implementation dates of price changes, but also due to yet missing functions that would still need to be programmed. For actual efficiencies, retroactive payments are tracked manually so far.

Assessment of Limitations

As illustrated, all the above mentioned limitations of the organizational background of MFTBC can potentially delude the result of material cost efficiency calculations. In order to understand to which extent those limitations actually affect the calculation accuracy of the presented methods, reported figures from material cost efficiency reports shall be considered. Table 5 shows reported efficiency results of the Actual Approach and the Frozen Volume Approach for full-year (FY) 2018 and YTD April 2019. All figures are stated in % of the total actual material cost efficiency of the regarded reporting period. The total actual material cost efficiency is the result of the efficiency calculated in the Power BI tool by the Actual Approach, adjusted by manual calculations. These manual calculations are applied to offset the presented limitations and therefore to give a realistic representation of actual material cost efficiencies.

	FY 2018	YTD 04/2019
Total Actual Material Cost Efficiency (Reference Level)	100.0%	100.0%
Result of Actual Approach	77.3%	88.2%
Deviation from reference level	-22.7%	-11.8%
t/o Part Number Changes	-21.9%	-8.0%
t/o Mid-Year Savings	-1.7%	-0.2%
t/o Retroactive Payments	+0.9%	-3.6%
t/o Price Changes within a month	0.0%	0.0%
Result of Frozen Volume Approach	135.1%	125.1%
Deviation from reference level	35.1%	25.1%

Table 5: Efficiency deviation measured by Actual Approach & Frozen Volume Approach in % of total actual efficiency (Daimler Intranet F, 2019), (Daimler Intranet C, 2019)

It can be seen that in comparison to the total efficiency that was reported for FY2018 and YTD 04/2019, the results of the Actual Approach generated by the Power BI tool only cover 77.3% and 88.2% efficiency respectively. Thus, the current implementation of the Actual Approach is yet not developed enough to give a full representation of the total actual cost efficiency. The Power BI tool underestimates the actual efficiency by -22.7% and -11.8%.

This can be directly traced back to the presented limitations. With -21.9% in FY2018 and -8% in YTD 04/2019, the biggest impact on total actual efficiency can be explained by part number changes. Therewith, part number changes also represent the biggest risk in actual efficiency calculation. The identification of part number changes is currently a very difficult task for material cost controlling at MFTBC since local IT systems used for production planning, purchasing or accounting activities are not necessarily interconnected. At the moment, a lot of manual work is needed to align information from different systems, which is needed to connect new part numbers with its predecessor part numbers. Ultimately, the current updating process of the Power BI tool via reports from the material cost consolidation system is very time intensive. Updates are not made often enough. Mid-year savings, retroactive payments and price changes within a month only reflect a comparatively small portion of the total actual efficiency, amounting together to -0.8% in YE2018 and -3.8% in YTD 04/2019. Due to the mentioned policy for commercial efficiencies that price changes have to be set at the beginning of the month, the effect of price changes within a month practically does not exist anymore.

But after all, comparing the results of both reports shows that there is a clear trend towards an improved efficiency coverage of the Actual Approach. Having been implemented in 2018, until today the implementation of this valuation method has been continuously improved by analyzing possible problems and optimizing the data processing along its value stream up to the final report.

In contrast, the efficiency calculated by the Frozen Volume Approach tends to overestimate commercial efficiencies. In FY2018, the Frozen Volume Approach overestimated the total actual efficiency by 35.1% and in YTD 04/2019 by 25.1%. This has mainly to do with the nature of planned EPU. According to internal communication, EPU is often planned too optimistically. For strategic reasons, high purchase volumes were consistently assumed across the entire material cost scope. In reality, these expected purchase volumes can usually not be realized during the business year and therefore discrepancies arise.

In comparison, both reports show that the Actual Approach tends to approximate the total actual efficiency better than the Frozen Volume Approach. Both, in YE2018 as well as in YTD 04/2019 the deviation of the Actual Approach from the reference level was significantly lower than the deviation of the Frozen Volume Approach from the reference level. For a final assessment, it should be considered that the numbers provided in Table 5 are all indexed to a manually adjusted total figure of actual efficiencies. Therefore, this

used reference level is not necessarily the truly achieved actual efficiency. But given the thorough analysis of possible limitations and its consideration in the made adjustments, it is a good approximation. Lastly, when taking into account that the Actual Approach increased its accuracy considerably from 2018 to 2019 and that there is still much potential for improvements, the Actual Approach can be considered as superior to the Frozen Volume Approach.

5.3 The Income Effect of Commercial Direct Material Cost Efficiencies

Apart from the steering of procurement activities, commercial direct material cost efficiencies in MFTBC are also used to explain material cost related developments of the company's profitability. In reporting, material cost controlling applies material cost efficiencies in particular to the earnings before interest and taxes (EBIT). EBIT, also known as the operating profit, is a profitability measure that gives insights into a company's ability to generate earnings based on its operating activities (Bodie, et al., 2017, p. 452). Since at MFTBC material costs contribute approximately 60% to the company's entire production costs (Personal Communication, 2019), additional insights on material costs, gained by for instance material cost efficiencies, can be very helpful to understand why the EBIT changes over the course of a year.

However, when taking a closer look at material cost efficiencies, it becomes obvious that they are based on the concept of purchasing costs. In order to relate to procurement performance of reducing material costs efficiently, costs are determined from a purchasing perspective by using purchasing volumes that are evaluated on the basis of a corresponding price component. This allows direct material cost efficiencies to be used as a key figure for the steering of procurement activities (Personal Communication, 2019). But when it comes to the calculation of the EBIT and explanations thereof, it must be critically reviewed if the commercial material cost efficiencies should be related to the EBIT. The EBIT is calculated based on the cost of goods sold and underlying production costs. Therefore, it cannot necessarily be related to purchasing costs (Bodie, et al., 2017, p. 452).

As illustrated in 2.1.3 Income Effects of Direct Material Costs, the calculation of direct material costs from an income perspective is dependent on the sales volume and the inventory valuation method that is applied to assign the incorporated material costs of consumed materials. Transferring this knowledge to commercial material cost efficiencies, the same limitations must be considered. The example shown in Figure 9 illustrates how the commercial material cost efficiency concept leads to different results

when the production volume exceeds the purchasing volume of a material in the same period. It is based on the assumption that price changes occurred at the beginning of a period, that stock is managed by the LIFO-method and that actual purchasing prices are applied.

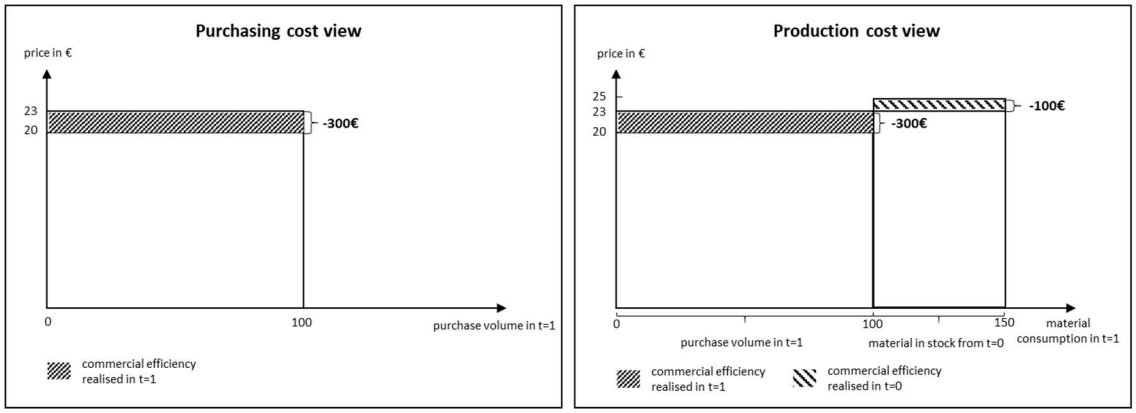

Figure 10: Commercial material cost efficiency - Purchasing cost vs. production cost

It can be seen that while in the purchasing cost view, the application of the commercial material cost efficiency concept leads to -300€ cost savings on M6, its application on production costs result in -400€ cost savings. This can be explained by analyzing the given volumes and related prices.

In t=1, the material consumption related production volume exceeds the purchasing volume by 50 units. In order to cover the production volume of 150 units, not only the purchasing volume of 100 units but also remaining 50 units from stock have been consumed. Following the LIFO inventory valuation method, first the recently in t=1 acquired purchasing volume of 100 units was depleted, before extra 50 units, bought in t=0 have been taken from stock. The purchasing volume in t=1 has been affected by a price decrease of -3€ from 23€ to 20€. This results in purchasing cost savings of -300€. The 50 units that have been taken from stock, on the other hand, is based on a different price development. In t=0, savings of -2€ (23€ - 25€) per unit have been achieved by buyers, which led to additional cost savings of -100€.

Combining the insights gained from section 2.1.3 Income Effects of Direct Material Costs and this example, it can be concluded that once the total volume of one material used in production has been purchased in different shipments and at different prices, the commercial direct material cost efficiency will differ from the production costs that have been incurred in a given period. This is frequently the case when purchasing volume and production volume differ from each other. The same accounts for the relation of

production costs and COGS. Once production volumes differ from sales volumes, it must be considered that the material costs incorporated in the COGS may come from different production periods, whose material inputs have also possibly been purchased at different prices.

Nonetheless, MFTBC decided to use actual material cost efficiencies, determined from a purchasing view, for internal reporting of EBIT changes. The main justification for this is that the production system is based on a just-in-time concept. Following this concept, MFTBC tries to minimize its inventory by aligning its material orders from suppliers directly with its own production schedule. Delivered production materials are therefore supposed to be consumed nearly immediately. Material costs bought in one period are assumed to be consumed in the same period. The production of trucks and buses is based on orders. For that reason, finished products are expected to be sold in the same period.

Considering that according to internal information nearly all material is consumed approximately within the first two weeks upon purchase order, just-in-time production may justify the application of purchasing costs as an approximation for EBIT related cost drivers. Since internal reporting is not subject to accounting rules, there is no legal obligation that should be considered. But from the perspective of internal cost control, the degree of inaccuracy that comes with this approach should be considered as critical. There are special cases such as imported material with lead times of up to three months that don't allow a direct correlation of purchasing and production costs. It should also be considered that despite just-in-time production, stock in the form of safety stock is held and further distorts results (Personal Communication, 2019).

6. Deduction of Potential Solutions for Improvement

The analysis of the presented valuation methods has shown that their application to calculate commercial material cost efficiencies at MFTBC is flawed. Based on the previous findings, the followingly described measures could be considered as potential solutions to improve the accuracy and usability of the Frozen Volume Approach and the Actual Approach.

Frozen Volume Approach:

Currently, the Frozen Volume Approach significantly overestimates the actual material cost efficiency. This can mainly be explained by an inefficient planning process of EPU, which leads to the identified volume effect. At one side, EPU planning is only conducted once in a year as part of a static budgeting process. A reliable prognosis for future market demands over the period of a year is not possible since the market demand is dependent on many external factors. On the other hand, further internal investigations have shown that the EPU planning process itself has become inefficient. In particular, the alignment of value streams for sales, production and material planning is considered problematic. (Personal Communication, 2019).

Opposed to static budgeting, the application of a flexible budgeting approach could help to improve the accuracy of efficiency tracking with DTA's current efficiency tracking system. Flexible budgeting is based on a planning set-up that allows different activity levels to be applied to an overall cost basis (Hope & Fraser, 1999). Considering that the regarded material cost efficiency is solely based on direct materials, which are by nature variable costs, activity levels could be directly applied. By improving the planning quality of EPU and making them dynamic through adaptation to changing activity levels, the efficiency tracking system could provide more value-add to the business. In comparison to the Power BI tool that is used for the Actual Approach, the efficiency tracking system is completely implemented within DTA, has many interfaces with other major systems such as the global procurement system and it has a high degree of automation. The deployment of two separate tracking approaches could therefore be rendered as unnecessary since it binds available capacities.

The flexible budget appears to be a good solution to a static planning approach. But it must be considered that while variable costs can directly be adjusted by activity levels, fixed costs must be assigned and accounted for by appropriate budget formulas (Drury, 2018, p. 391). Considering the production volume at MFTBC, this was not only very

resource intensive, but it also required a sophisticated change management approach to reshape historically grown and deep-rooted planning processes to a new operational planning approach.

Actual Approach:

The Actual Approach has been established to provide a realistic representation of actual cost developments. While its underlying concept of using exclusively actual data is pertinent, the organizational environment at MFBTC poses grave limitations to its calculation accuracy and usability. For the calculation of commercial material cost efficiencies with the Actual Approach, the accessibility of required data is very critical. At MFTBC, data is dispersed into many different IT systems that are only partially interconnected. In order to use data for analytical purposes, data must first be gathered and aggregated. The example of extracting price information from the global procurement system by using the material cost consolidation system as an intermediate system shows that processes become more inefficient and more difficult to be handled, the longer the value stream becomes. In this example, the extraction of price information is limited to monthly updates, since the material cost consolidation system does not provide shorter update cycles.

Although the given example identifies the material cost consolidation system as a problem, its underlying concept on the other hand may also be a solution. By unifying all data in a central data warehouse that serves as a single source of truth, processes could be made more efficient and a general improvement of data quality through central data management could be achieved. Until today, the monthly update of the Power BI tool for the Actual Approach takes three work days to obtain, aggregate, consolidate and double check all data. The application of one single data source not only reduced a considerable amount of manual work but also ensured that all data is consolidated and can be directly used for analysis.

Data consolidation is in fact part of many current projects at MFTBC. In controlling, the creation of business warehouses is heavily promoted. But the development and implementation of IT solutions require both, know-how and commitment. The realization of those projects takes time since its initiation is part of long internal approval processes. One reason for this is that the implementation of IT-solutions is bound to substantial financial investments, which requires costs and benefits to be weighed against each other.

7. Conclusion

This thesis has analyzed the application of three valuation methods that were initially considered as potentially suitable to calculate commercial direct material cost efficiencies at Mitsubishi Fuso Bus and Truck Corporation. While the Frozen Volume Approach and the Actual Approach are valuation methods currently in use, the Direct Material Price Variance has been considered as an alternative method.

The examination of each valuation method has shown that each method not only uses different data sets but is also limited by the way it is implemented and its organizational context at MFTBC. Table 6 summarizes the special characteristics of each valuation method's underlying data.

	Frozen Vol. Approach	**Actual Approach**	**Price Variance**
Price component	actual purchasing price	actual purchasing price	standard/ actual price
Update frequency	daily	monthly	annually/daily
Quantity component	EPU	actual quantities	actual quantities
Update frequency	annually	monthly	daily

Table 6: Comparison: The valuation methods and their underlying data

All valuation methods differ from each other either by applying actual data only, like the Actual Approach or by using a mix of actual and planned data. The update cycles differ from daily updates for actual data up to a year for planned data. In combination, this leads to very different results.

The sample calculation of example 1 illustrated how the calculation principle of each valuation method and its underlying data differ from each other when examined isolated from their organizational background. Based on its calculation principle, the Actual Approach can be considered as the most accurate valuation method, since only actual data is applied. The other two approaches differ from the Actual Approach because they are applying different planned data. Using annual planned EPU as an approximation for the purchasing volume of a material, the Frozen Volume Approach tends to overestimate the actual efficiency due to volume targets that have been set too high during the planning period and cannot be achieved in actual business. On the other hand, the Direct Material Cost Variance tends to deviate from actual efficiency results since the use of standard prices leads to distorting price effects. These insights illustrate that the precise calculation of cost efficiencies is strongly dependent on how well-planned data has been

set. Nevertheless, no matter how well data is extrapolated, deviations to actual data will always occur and will cause deviations from actual data.

In a second step, it has been examined how the implementation of the valuation methods and their overall business context affect their usability at MFTBC.

Table 7 shows an overview of all mayor limitations that can potentially delude calculated results.

	Frozen Vol. Approach	**Actual Approach**	**Price Variance**
Distinction of PCRCs	yes	yes	no
Calculation of:			
Part Number Changes	no	no	n/a
Mid-year savings	no	no	n/a
Price Changes within a month	yes	no	n/a
Retroactive Payments	no	no	n/a

Table 7: Comparison: Limitations at MFTBC

The distinction of price change reasons has been identified as one of the most important capabilities that are required for the calculation of commercial material cost efficiencies. The Direct Material Price Variance cannot provide a distinction of price change reasons. Its calculation principle is generally suited to calculate commercial efficiencies as long as price changes are only composed of commercially related price changes. However, due to multiple price effects in the business environment of MFTBC, it is not usable.

The other identified limitations were therefore only applied to the Frozen Volume Approach and the Actual Approach. The analysis of each limitation showed that business related reasons such as part number changes and retroactive payments, but also software related reasons (see mid-year changes, price changes within a month) pose potential problems for the calculation accuracy of each method. As of today, both valuation methods are directly affected by those limitations. Thus, manual adjustments need to be done to achieve the desired degree of accuracy. By using efficiency reports of FY2018 and YTD 04/2019 these limitations have been evaluated based on its monetary impact on the overall efficiency result of each method. Following the YTD 04/2019 report, the Actual Approach currently underestimates the actually incurred total efficiency by an inaccuracy of -11.8%. The Frozen Volume Approach, on the other hand, overestimates the targeted actual efficiency by 25.1%. This result showed that the Actual Approach not only tends to calculate the actual commercial direct material cost efficiency

more accurately but also has improved its accuracy tremendously compared to an inaccuracy of -22.7% for FY2018.

Further analysis has revealed that the use of commercial material cost efficiencies to explain developments of the income level at MFTBC are problematic. As pure purchasing costs, material cost efficiencies vary from the calculation of the EBIT by using purchasing volumes instead of sales volumes. Principally, purchasing costs can only be assumed to be COGS if the material consumption of goods sold in a period equals the purchasing volume of that period. At FUSO, this is not the case, but due to just-in-time production, the majority of all material is consumed within two weeks upon purchase order and all products are directly sold. Considering that commercial direct material cost efficiencies do not give a perfect representation of the COGS, they can only be used as an approximation for EBIT changes in internal reporting.

The Frozen Volume Approach is a planning tool sufficiently able to provide procurement with substantial data for the steering of its activities. However, when it comes to the calculation of an actual cost impact on the EBIT of MFTBC, the current implementation status of the Actual Approach not only provides a higher level of information accuracy but also reflects actual cost developments in a better way. Both methods are potentially usable, but with the given organizational limitations, the Actual Approach should be preferred.

Nevertheless, it should be addressed that the presented limitations that are posed upon the valuation of material cost efficiencies are exclusively technical limitations. The analysis of the theoretical concept that lies behind the regarded valuation methods shows that for the purpose of calculating actual cost effects, only the Actual Approach is truly eligible. Although this approach already out-performs the other valuation methods despite all given technical limitations, it should be the highest priority of MFTBC to establish a business environment that enables its deployment without any business, organization or process related restrictions. As possible solutions, the application of a flexible budgeting method for the EPU planning of the Frozen Volume Approach and the implementation of a central data warehouse to improve overall data quality and accessibility for the Actual Approach have been deducted. Both measures present sufficient justification to be implemented, but organizational and financial limitations suggest that these changes will at best be subject to a gradually progressing change management process that may last year.

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Affidavit

I hereby confirm that my thesis entitled “Direct Material Cost Efficiency Analysis - An Assessment of Valuation Methods at Mitsubishi Fuso Truck and Bus Corporation” is the result of my own work. I did not receive any help or support from commercial consultants. All sources and/or materials applied are listed and specified in the thesis.

Furthermore, I confirm that this thesis has not yet been submitted as part of another examination process neither in identical nor in similar form.

X

Marlon Möller 06/23/2019