

Editorial

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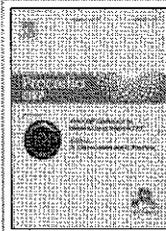
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Laboratory for Manufacturing Systems and Automation (LMS)
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Edited by G. Chryssolouris and D. Mourtzis

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Method to Determine and Quantify Changes in Value Chains Caused by E-mobility

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Abstract

Increasing production and sales figures for electrically powered vehicles affect the medium term value chains of the automotive industry. Due to the importance to the automotive industry for national economies or economic areas, the issue of determining the medium-term effects arises as a result. To this end, a method for the determination and quantification of e-mobility-induced changes has been developed, using Austria as an example. The method presented in this paper has been developed in the course of a study assigned by the Austrian Federal Ministry of Economy, Family and Youth, the Austrian Economic Chambers and Federation of Austrian Industries.

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Keywords: Automotive Industry; E-Mobility ; Value Chain ; Value Added Effects; Employment Effects

1. Introduction

Increasing production and sales figures for electrically powered vehicles affect the medium term value chains of the automotive industry. Some components of vehicles with conventional internal combustion engines are experiencing declining demand and are being replaced by the electrification of the drivetrain, either partially or totally. This leads - in dependence of the unit numbers of individual drive concepts - to value added shifts for the companies involved or also for industries which are part of the development and production processes of drive components. Within the scope of this work, a methodology will be introduced that allows a forecast and quantification of the effects of electric mobility on vehicle-specific national value added chains.

Previous approaches to determine and quantify changes in automotive value-chains caused by e-

mobility are either rudimental, describing value-added shifts from mechanical to electric/electro-mechanic value added in a qualitative manner [1], [2], or scientifically founded, using complex input-output-models to quantify the effects [3]. The initially mentioned, general descriptions of the value-added shifts, however, permit no derivation of quantitative magnitudes for the description of the effects on domestic value added chains. Input-output tables, the database for input-output (IO) models, illustrate the inter-industry relations within a national economy, and, hence, allow the description of the service relationships of the respective sectors of a national economy to each other [4]. Meade [3] analyses the macroeconomic effects of electric mobility in the USA, using a model called INFORUM-LIFT, which is an input-output-model for the analysis of the developments of the American national economy. To this end, assumptions are made with regard to domestic market penetration and

production of vehicles and charging stations in order to estimate the effects on the input-coefficients on the basis of the respective technical changes and to compute, finally, the macroeconomic effects. Meade arrives at the conclusion that electric mobility causes a low macroeconomic effect when using the assumed low market penetration as a basis. But, nevertheless, individual industry fields will be significantly influenced. A detailed analysis on industry sectors or components was not conducted.

The use of input-output models is principally suited for the analysis of the effects on the domestic value added chains. However, the determination of preferably exact and market based input-coefficients is crucial to the models result. Hence, a higher level of granularity in respect of the technical analysis is necessary and was considered within the presented method.

Using the example of Austria characterized by a high number of established automotive suppliers and no domestic OEM, the use of national total vehicle production numbers as model variable, as used in the model of Meade, would result in misleading effects. Therefore the presented model examines the national automotive production potential on the more detailed level of components and sub-components. The methodology thus developed, therefore, allows for making a sound statement about extent and direction of electro-mobility related value added shifts, based on technological shifts and sub-component related market shares of the respective nation under investigation. The method presented in this paper has been developed in the course of a study assigned by the Austrian Federal Ministry of Economy, Family and Youth, the Austrian Economic Chambers and Federation of Austrian Industries [5].

2. Problem formulation

On account of the international integration of automotive value added chains and the focus of national value added chains on certain areas or sections of the value added, a uniform distribution of the national value added proportions in the global value added cannot be assumed across all the components of a given vehicle. Looking at the example of Austria, the nation holds 0.2% of the global market for total vehicles, but 2.5% of the world global for internal combustion engines or, more generally speaking, 0.25% of the global market for electronic components and 2% for mechanical components. The neighbouring country of Germany, in comparison, already holds 9.5% of the global market share vehicles. Thus, a differentiated analysis of market shares at the component and part level is required.

In order to determine the value added shifts for existing parts, mean production costs, mean national

value added and value added depth, as well as mean value added per employee can be used as reference. A similar approach of using these mean statistics was used in [6] to determine the value added an employee effects of charging infrastructures on Germany, or rather the region Baden-Württemberg.

However, what is more difficult here is the forecast for components for which no statistical data is available yet. This encompasses all electric-mobile induced components. For their calculation and potential determination, there is a need to disassemble them into part components until an unequivocal assignment to a certain sector of industry is possible. Using the production costs resulting in this disassembled state as a basis, conclusions can be drawn in turn, with the help of the corresponding industry sector's key performance indicators, regarding the value added potentials and employee figures.

With the help of the production figures of passenger cars and a predicted change across time, the national value added shift and number of employees can be determined, therefore. On this occasion, it is necessary - for certain, highly complicated parts - to consider existing production capacities and their capacity limits. Whether a new investment is to be expected, for new capacities in the case of growth, is something that can only be assumed with a certain probability which orientates itself on general location factors and a mastering of technology by individual resident companies. Thus, for example, a maximum production capacity is installed in Austria of 250,000 units for complete vehicles - a further increase would be possible only by means of a new construction of a passenger vehicle factory. The probability that this could be set up in Austria, however, seems to be very low. With general components in the area of electronics or mechanics, there is no need to assume a basic capacity bottleneck.

3. Approach

The method is based on five defined passenger car-vehicle concepts which differ concerning drive, exhaust aftertreatment, power transmission and the energy storage; however, they are comparable in terms of road performance. Building on an analysis of the technological changes inside the vehicle, the vehicle components affected by this are evaluated according to production costs. Using an assignment of the components to the industry classification applied in the national accounts, the absolute value added potentials per vehicle can be determined from the production costs by using the assigned industry key performance indicators. Furthermore, a market analysis, which is created in each case for the value added-driving components, is used to determine and predict just how

strongly the international value added integration is coined in these areas and in which fields the national economy is at its strongest. Using this as a basis, it is possible to derive which respective proportions of the worldwide expected unit numbers will have a nationwide impact and, therefore, which direct value added effect this is going to entail at national level. Figure 1 outlines the approach to quantify the value-added and employee effects of e-mobility on national economies.

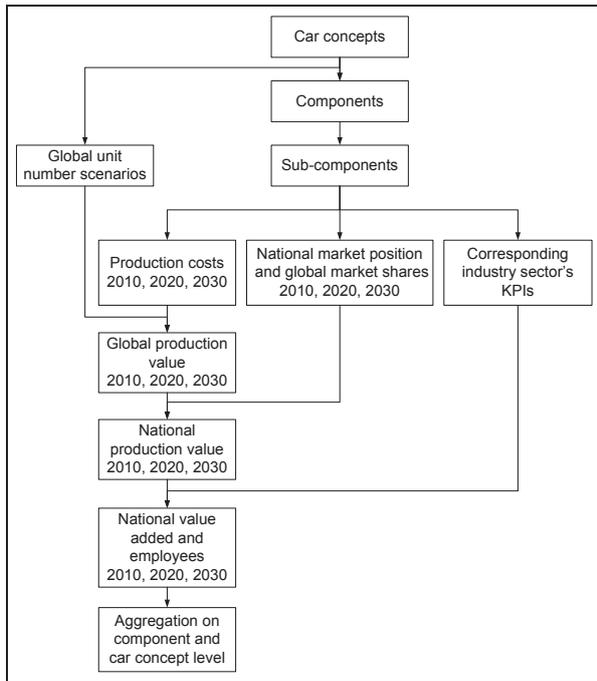


Fig. 1. Approach to quantify value chain effects caused by e-mobility

3.1. Production costs of vehicles

Based on a classical internal combustion engine reference vehicle (RV), the following vehicle concepts for electric mobility have been defined: Plug-In-Hybrid electric vehicle (PHEV), Range-Extender vehicle (REV), battery electric vehicle (BEV) and fuel cell electric vehicle (FCEV). At component level, three different types can be identified in the five vehicle concepts: unchanged components, components affected by changes and new electric mobility components. New components and components affected by changes were evaluated for the individual vehicle concepts according to production costs and were forecast for 2020 as well as in 2030, taking into account learning effects and experience effects on account of rising unit numbers, new technologies and materials as well as increased efficiencies in the production processes (see figure 2).

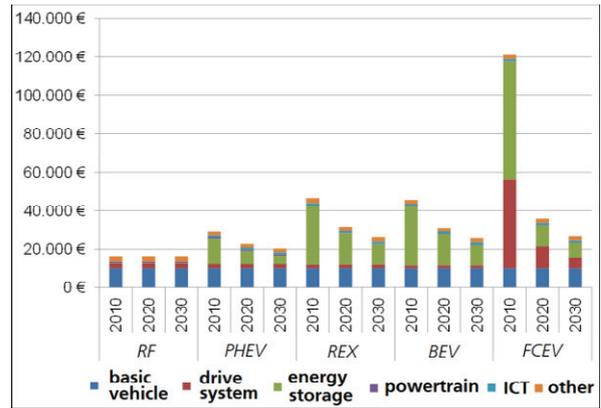


Fig. 2. Production costs of vehicle concepts from 2010 to 2030

3.2. Unit number scenarios

On the basis of existing studies, e.g. [7], [8], [9], [10], as well as with the help of OEM expert surveys and Technology Readiness Level estimates, a unit number scenario was developed for the five vehicle concepts for the years from 2010 to 2030 (see Figure 3). Within this “demand scenario” the most likely trends concerning e.g. technological development, user behaviour patterns, governmental strategies and regulatory frameworks were taken into account. However, there are uncertainties comprised when forecasting these production figures.

Therefore the “supply-scenario” was introduced that emanates from a standardised production volume of one million units of a respective vehicle concept. This scenario helps to evaluate the value added and employee potential solely based on the national industries competences on certain technologies or products of a vehicle.

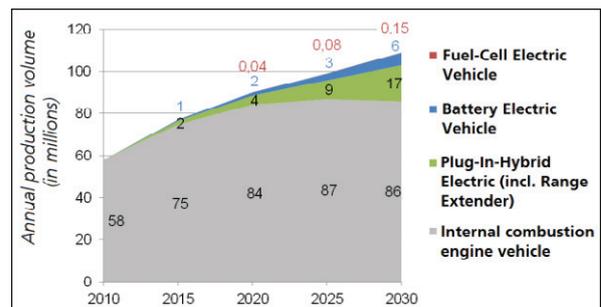


Fig. 3. Annual production volumes of vehicle concepts from 2010 to 2030

3.3. National global market shares

As described in section 2, a uniform distribution of a national value added proportions in the global value added cannot be assumed across all the components of a given vehicle. Furthermore, the available national statistical data and the production volumes or market shares published by leading national companies respectively vary across these components and their sub-components. For new electric mobile components there is no statistical data available at all. Therefore, the method comprises different calculations and estimations of market shares for the components and their particular sub-components:

- Use of statistical data published by the International Organization of Motor Vehicle Manufacturers (OICA) [11] and national statistical authorities, e.g. Statistics Austria [12] and the automotive trade association Austria [13].
- Use of leading companies' production figures or market shares published in their annual reports.
- Use of industry specific market surveys published by renowned market research institutes.
- Specifically realised surveys among existing national automotive suppliers as well as potential suppliers for electric mobile components and sub-components.

In the following, the identified and calculated national global market shares are used as initial values for the year 2010. Changes in market shares due to market developments during the following 20 years of period under consideration are estimated by a qualitative analysis of the national companies' market position in an international context.

3.4. National market position

On account of the international integration of automobile value added chains, the existing and theoretical potentials of the national companies must be put in context concerning international competition. Using research for the identification of the "global players" in the technology fields and product fields concerned, the competitive environment is evaluated for the different subassemblies and components. In subassembly-related market potential portfolios, the national position can be qualitatively evaluated as a function of competitive environments and/or market entry barriers as well as the competence of national companies. It allows to qualitatively evaluate the companies' ability to position themselves in the markets for new technologies and products (see figure 4).

International competitiveness market entry barriers	low	neutral	high	very high
	medium	low	neutral	high
	high	very low	low	neutral
		low	medium	high
		National companies' competences		

Fig. 4. Market potential matrix

This classification, in connection with determined average existing market shares of the national automotive industry relative to the global automotive value added, allows a forecast of potential market shares for the consideration period until the year 2030. The market shares calculated that way are validated with the help of an expert and company survey and were standardised.

3.5. Industry key performance indicators

In order to calculate the value added and employee effects of production costs incurred in an national economy, corresponding industry key performance indicators, namely mean national value added and value added depth, as well as mean value added per employee can be used as reference. These indicators, structured in sectors of industry, are provided by national statistical authorities. The structuring allows assigning the sub-components unequivocally to their respective key performance indicators.

3.6. Effect on national value added chains

Using the global market shares determined at component level in connection with the component-related industry key performance indicators, finally, the value added impact and the impact on employment on the respective country can be calculated with the help of the unit number scenarios. Due to the detailed analysis on sub-component level the effects can be aggregated on component- or car concept-level.

4. Results

In the course of the study two levels of findings can be achieved. Firstly, the global value added shifts caused by electric mobility can be calculated in principle. Secondly, the subsequent national value added and employee effects can be measured with regard to affected sectors of industry and with regard to the components and subcomponents inducing these effects.

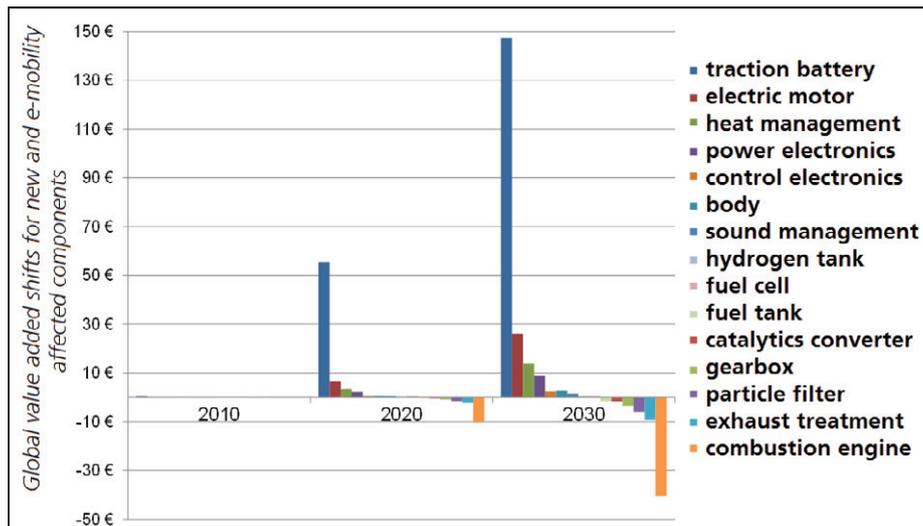


Fig. 5. Shifts in value added for new and e-mobility-affected components (global)

4.1. Global value added shifts

Global value added shifts can be forecast at component level across the years under consideration (see figure 5).

If one compares global total value creation, taking into account electric mobility, it can be seen that this is higher in sum total than it would be when taken for conventional vehicles alone. The concepts of the electric mobility, therefore, lead to an overall higher value added in the automotive field. This is, above all, due to the high value added contribution in the area of traction batteries.

4.2. Effect on national value added chains

Using the global market shares determined at component level in connection with the component-related industry key performance indicators, finally, the value added impact and the impact on employment on the respective country can be calculated with the help of the unit number scenarios.

Another aspect with regard to the shift of national value added is the traction batteries' charging infrastructure necessary for electric mobility as well as hydrogen filling stations. Here, a clearly lower correlation is to be expected between worldwide production unit numbers and national values added. For instance, the sales of charging stations are primarily dependent on the number of electric vehicles in use. Hence, regional electric mobility proportions relative to the overall vehicle stock must be taken into account for infrastructure facilities. Using the average unit number growth factor of electric vehicles and the cost-based

assessment of the charging stations, the national value added and the national impact on employment can be determined here in like manner to the approach with passenger vehicle components.

Figure 6 uses Austria as an example for the direct employment trend in automotive production using the “demand-scenario”. This consists of the additional employment potential for new components of electric mobility and the infrastructure, the positive as well as negative impacts on employment on the components affected by changes, as well as the components not affected by changes.

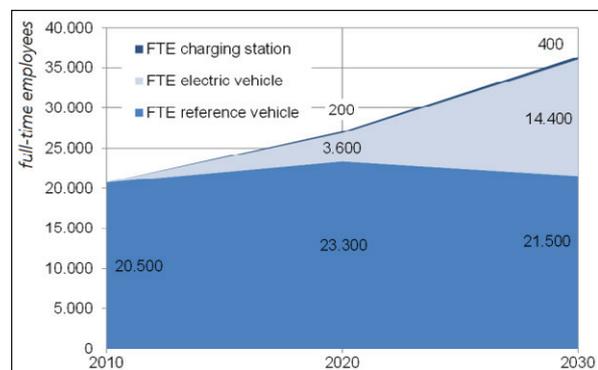


Fig. 6. Development of direct employees in car production in Austria (demand-scenario)

When using the “supply-scenario”, the theoretical effects on the national value added chain and employees respectively of a global production volume of one million units of a specific vehicle concept can be derived. Figure 7 uses Austria as an example for these effects, showing that certain components with high

effects on the national economy are used in multiple vehicle concepts (so called multi-use-components), e.g. electric motor, traction battery, power electronics) whereas the hydrogen tank has the highest theoretical impact on the national economy but is only used in the fuel-cell electric vehicle. Furthermore it can be shown that the theoretical impact on the national economy of electric vehicles compared to the reference vehicle is higher for all the electric vehicle concepts.

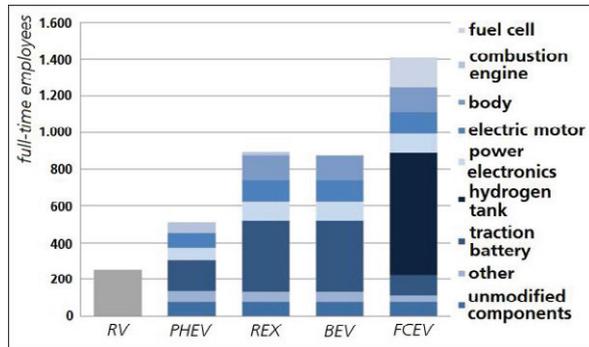


Fig. 7. Direct employees per vehicle concept and component in Austria (supply-scenario)

5. Summary

The benefit of the method presented here, on the one hand, is in the findings from the competition analysis and competitor analysis and, on the other hand, the concrete determination of the value added potential. The advantages are briefly outlined below.

Competition analysis and competitor analysis:

- Pointing out national strengths for electric mobility
 - Targeted use of national strengths by international comparison
 - Identification of market opportunities which are internationally not exploited to capacity and of already exceptionally competitive fields
- Value added potential determination:
- Improved risk evaluation for the existing national automotive industry
 - Early reaction to qualification requirements in the industry
 - Specific promotion of nationally especially relevant technologies and competencies
 - Selection and promotion of technologies with high international unique selling proposition with, at the same time, high employment effect
 - Targeted use of political grants and financial support measures in view of national value added effect

On account of the granularity, the model allows for different statements with regard to the employment trend. Thus, it is possible, for example, to determine industry-specific effects in such areas as mechanical or electric component manufacture, or even component-

related or product-specific effects. Taking into account the multi-round effects on account of the national service integration, direct employment potentials can be used as a basis for drawing conclusions about indirect employment.

One aspect to be criticised here is that the methodology assumes a linear, continuous development in the subject area of electric mobility. Technology leaps, radical social or political change and corporate policy decisions of major impact cannot be registered and/or predicted by this method. Methods from the field of scenario engineering could be used here as well.

Another aspect to be criticised is that until now the production of passenger cars and basic home-charging stations were taken into account. Other aspects of electric mobility, e.g. utility vehicles, bicycles and business models are not considered but will lead to additional effects.

Further research will aim on two major topics: firstly, the focus of research in respect of vehicles and business models will be broadened. Secondly, the multi-round effects of the identified direct value added and employee effects will be modelled and calculated.

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