Basic Results of the Multiregional Health Account for Germany - Validation of Direct Effects of the Health Economy

Schwärzler, Marion Cornelia and Kronenberg, Tobias

WifOR Darmstadt, Bochum University of Applied Sciences

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Marion Cornelia Schwärzler[1], Tobias Kronenberg[2]

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Abstract: The Multiregional Health Account is a satellite account focusing on the economic impact of the health economy in German federal states. It was developed as an enhancement of the existing National Health Account for Germany. In contrast to the subject of matter over here, the calculations of the National Health Account are based on available national supply and use tables. Since there are no according tables available for the German federal states, we developed a methodology, which allows to calculate supply and use tables at the subnational multiregional level. The present paper focusses on the results of the MRHA for the reason of a thorough validation procedure of the developed approach. We evaluate regional direct effects of the health economy by comparing derived characteristics with company data and evaluate the performance of the algorithm in a time series. We find that the elaborated approach shows reasonable results in both dimensions evaluated.

JEL Classification: C67, E01, I15, R11, R15

Key words: national accounts, satellite account, health economy, Germany, regionalization, supply and use tables, SUT-RAS

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[1] WifOR, Darmstadt
[2] Bochum University of Applied Sciences

1 Introduction

Both the National (NHA) and the Multiregional Health Account of Germany (MRHA) refer to satellite accounts of the health economy and aim to quantify the economic contribution of this cross-sectoral industry in terms of gross value added (GVA), employment and trade. Unlike the MRHA, the concept of the NHA already exists for several years, promoted and initiated by activities of the Federal Ministry for Economic Affairs and Energy (Henke et al., 2010; Ostwald et al., 2014; BMWi, 2015, 2016, 2017a; Schneider, et al., 2016). The MRHA was published in 2017 and extends the existent calculations by a regional component (BMWi, 2017b).

In order to assure consistency of national and multiregional results, we pursued the intention to apply the same methodology of satellite account compilation in both cases. This approach is based on the elaborated methodology, which was devised over several years in the context of the NHA (Schwärzler & Kronenberg, 2017a). This intention, however, leads to a great challenge. The NHA is based on official supply and use tables of national accounts. Since there are no such tables available for the federal states of Germany, multiregional supply and use tables had to be compiled first.

Hence, we developed the MR-SUT-RAS algorithm to calculate multiregional supply and use tables. This approach derives from the SUT-RAS algorithm of Temurshoev & Timmer (2011) and was further developed for the multiregional case in the context of compiling the MRHA (Schwärzler & Kronenberg, 2017b). The elaborated procedure is an iterative algorithm, which incorporates all given information simultaneously, balances supply and use table mutually and is restricted by meeting national values in industries and products. The concept of the MR-SUT-RAS relies on the economic conditions and therefore the fact that all supplied output is used at some place. Regional diversification and specialization hence leads to interregional interaction and interdependencies.

After presenting the motivation for this paper in section 2, we show the basic results of the MRHA, including direct effects of the overall health economy, its subcategories and fields of specialization of federal states in section 3. Moreover, we apply the elaborated approach for several different years in order to analyze the development of the health economy in German federal states over time in section 4. We close the paper with concluding remarks in section 5. Since calculations were conducted on behalf of the Federal Ministry for Economic Affairs and Energy, the description of results in section 3.1 and 4.1 mostly refers to the corresponding report, BMWi (2017b).

2 Motivation

In this paper, we focus on the results of the MRHA in order to challenge the elaborated algorithm, MR-SUT-RAS. Hence, it is our intention to critically scrutinize the reliability of the approach before applying it to answer specific economic policy issues. This proceeding is especially challenging since no official supply and use tables are available for German federal states. Therefore, it is reasonable to question the reliability of the approach in the context of a satellite account, which allows to focus on a specific field of the economy. This way, we are able to oppose and compare results with qualitative information or related but not in the calculation integrated data. Since we carry out calculations in the context of the health economy on a wider

basis already for several years, we can fall back on knowledge, which favors the focus on the health economy in this context.

Focusing on industry information of multiregional supply and use tables does not lead to new findings, since corresponding values refer to data directly applied to the model. However, compiling a satellite account in accordance to the methodology developed in the context of the NHA allows us to concentrate on the product-specific defined health economy, which accordingly refers to modelled information. Hence, we can reasonably question the reliability of the elaborated model from this perspective.

Our main database for the MRHA, the national supply and use tables, refer to the years 2010 and 2011. They correspond to the statistical standards of NACE 2008 and ESA 2010. In Schwärzler & Kronenberg (2016) we depict on how to project these available tables for the years before and after the referring point of time. This procedure is necessary in order to quantify the contribution of the national health economy for the corresponding years, since generic tables on supply and use tables consistent with the latest statistical standards are available for the years 2010, 2011 and 2012 only at the time of writing.[2] We present results of the MRHA for 2011 in section 3, since our latest official national supply and use tables refer to this very same year. Accordingly, we present direct effects for the years 2006 to 2015 in section 4 to show that the elaborated approach manages to depict the macroeconomic development of the health economy despite the lack of generic national supply and use tables for all these years.

As aforementioned, we aim to challenge the developed approach of the MR-SUT-RAS in this paper. In a subsequent step, we evaluate indirect effects of the health economy in order to challenge a further dimension of the elaborated model (Schwärzler & Kronenberg, 2017c). The overall goal of the MRHA is to focus on interregional spillover effects from patient treatment and resulting implications on the lagging investments in German hospitals (Schwärzler & Kronenberg, 2017d).

3 Direct effects of the health economy in 2011

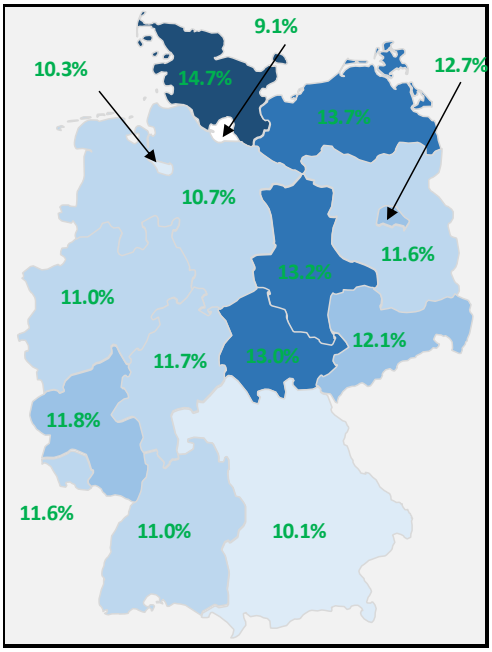
In this section, we focus on the direct effects of the health economy in German federal states for the year 2011. This includes the main economic indicators GVA, employment, export and import of the overall health economy in subsection 3.1. This way, we are able to present the big picture of heterogeneity German federal states exhibit in the case of the health economy. We show this in order to reach out for the reader's attention towards the need for the MRHA. In subsection 3.2, we look at a specific field of the health economy in order to challenge obtained results with secondary data. In this context, we make use of the fact that federal states exhibit a great heterogeneity in their specialization regarding the supply of medication in terms of manufacturing, R&D and wholesale. We challenge results with company data in order to see whether the algorithm is capable of elaborating the same characteristics of federal states observed in reality.

[2] Tables for 2012 are not available due to high costs involved.

3.1 The overall health economy in the German federal states in 2011

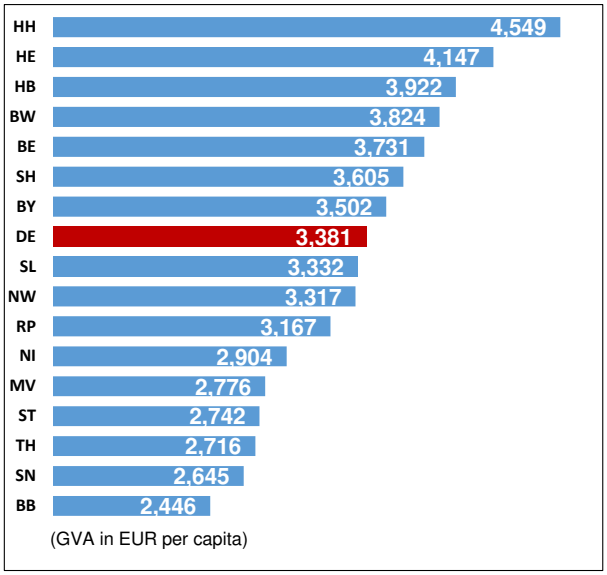
The German health economy contributes 11.2 percent to overall GVA in the year 2011. Figure 1 exhibits this indicator for the federal states, ranging between 14.7 in Schleswig-Holstein and 9.1 percent in Hamburg. We can depict an East-West divide to some extent. All new German Laender including Berlin show an above average share of the health economy. In Western German states, the sector exhibits outstanding significance for the overall economy only in Schleswig-Holstein, Rhineland-Palatinate, Hesse and Saarland. The health economy shows low significance for the overall economy of the city states Hamburg and Bremen and the economy of Bavaria. The latter is characterized by several well performing industries contributing to a high GDP per capita of this federal state. This causes the health economy to be of minor significance for the overall economy. Hence, we see the necessity to consider a further indicator, which is unrelated with the overall economic structure of the respective federal state.

Figure 1: GVA share of the health economy, 2011



Source: own illustration based on BMWi (2017b).

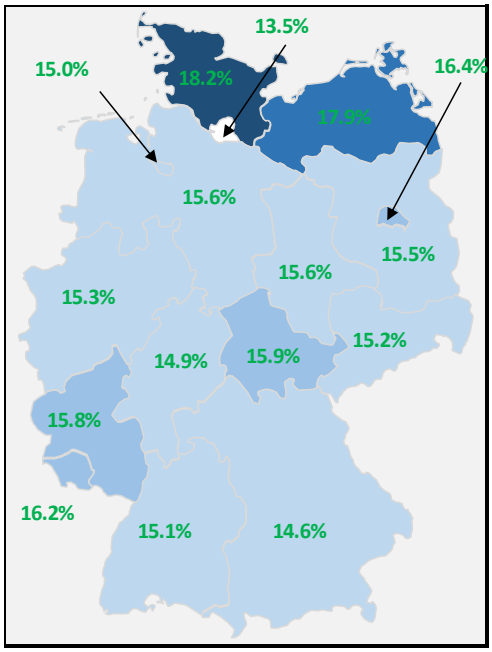
Figure 2: GVA of the health economy per inhabitant, 2011



Source: own illustration based on BMWi (2017b).

GVA per capita generated by the health economy reveals the performance of the industry opposed to its significance for the overall economy as previously described. As exemplified by Hamburg, we observe the difference of these two indicators. Hamburg obtains a well performing overall economy, resulting in a high GDP per capita. Accordingly, the influence of the health economy – and hence its significance for the overall economy – is low. This is due to the fact that the health economy is a considerably stable part of the economy with a relatively low range of possible outcomes compared to other industries. Hence, the indicator of the industry's performance offers an additional perspective, placing Hamburg at the top of the ranking.

Figure 3: Employment share of the health economy, 2011

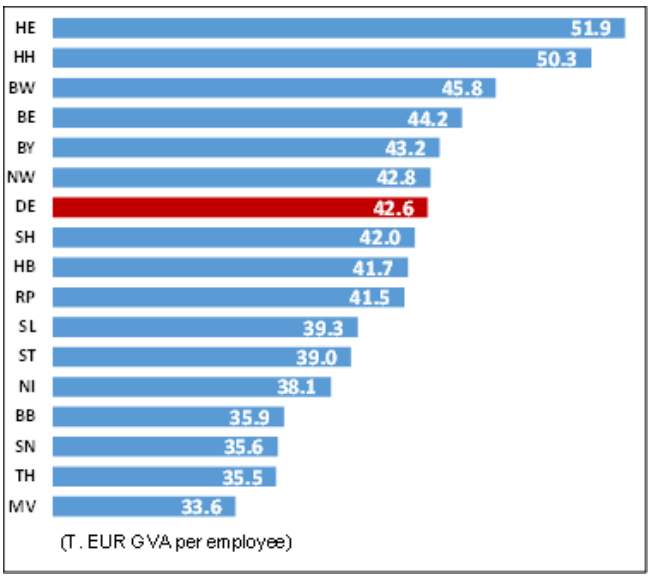


Source: own illustration based on BMWi (2017b).

In the following, we present figures on the significance of the health economy for employment in accordance to the previously shown GVA share of the health economy. The overall German health economy contributes 15.3 percent to employment in 2011. Again, this indicator shows a great variation among federal states, which is 13.5 percent in Hamburg and 18.2 percent in Schleswig-Holstein. In general, a high share of employees working in the health economy points towards a labor-intensive service orientation of the respective health economy. This is especially the case when we observe great disparities between GVA and employment shares. We hence conclude that the health economy in the federal states Lower Saxony, Bremen, Saarland and Bavaria are above average characterized by a high labor intensity, since they show the biggest gaps between GVA and employment share of the health economy among federal states.

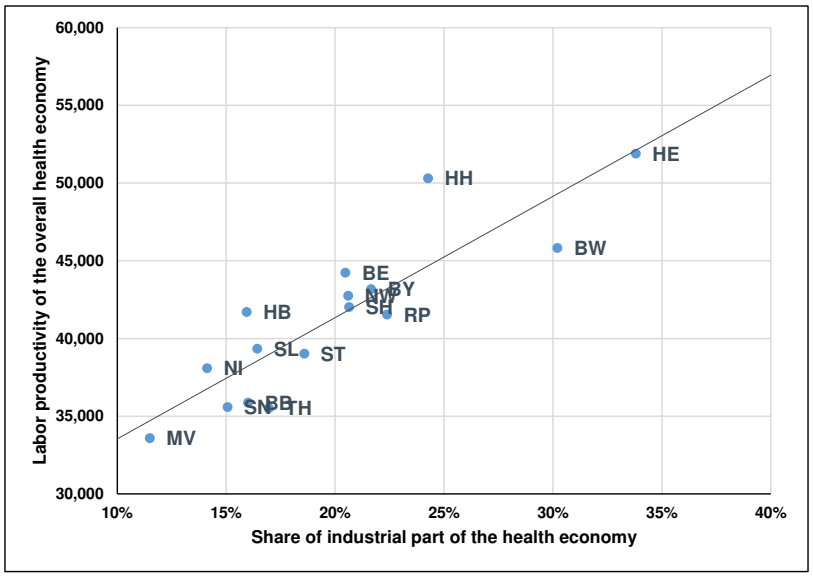
Productivity is in some way related to the conclusions just described, since it provides an additional perspective on the matter of specialization the health economies of federal states exhibit. We define productivity as the ratio of GVA per employee. The overall German health economy is characterized by a relatively low productivity compared to the overall economy. While the latter shows a productivity level of 58,400 € of GVA per employee, the health economy is characterized by a productivity level of 42,600 € GVA per employee in the year 2011. Reasons for this difference are the high labor intensity of the health economy accompanied by a relatively low degree of automatization of processes compared to manufacturing industries. The cross federal state comparison exhibits the highest level of productivity for Hesse with 51,900 € GVA per employee. This corresponds to a more than 20 percent gap between the average German level and Hesse. Moreover, among all Western German federal states, this one shows the lowest gap between the productivity of the health economy compared to the overall economy.

Figure 4: Productivity of the health economy, 2011



Source: own illustration based on BMWi (2017b).

Figure 5: Relationship between labor productivity of the health economy and share of industrial segment, 2011

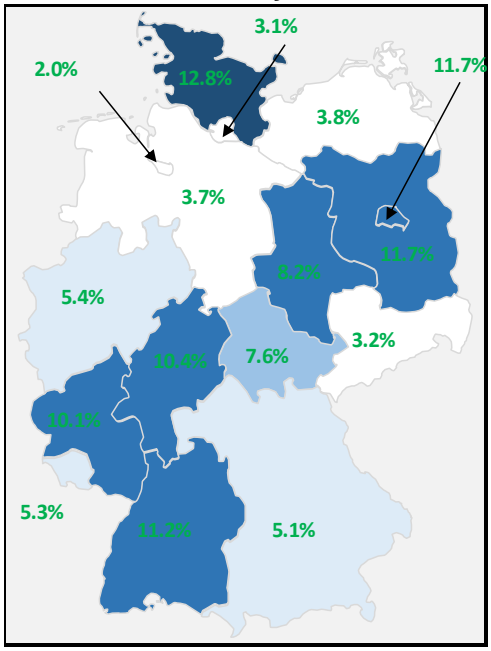


Source: own illustration based on BMWi (2017b).

Key driver of this circumstance is the high amount of medication manufacturing taking place in Hesse. Operating companies are for example Sanofi-Aventis Deutschland GmbH and Merck KGaA. In general, we observe a relationship between the significance of the industrial segment of the health economy on the one hand and the level of productivity of the health economy on the other hand, as shown in Figure 5.[3] Since labor productivity of the overall economy is below-average for all Eastern German federal states in 2011 (VGRdL, 2016), it is essential to be aware of the general discrepancy of productivity levels among Eastern and Western German federal states in this case.

The German health economy contributes 7.0 percent to international exports in 2011. There is only minor significance of exports in the Hanseatic Cities Bremen and Hamburg with 2.0 and 3.1 percent. In contrary, the health economy has relatively large impact on overall international exports in Schleswig-Holstein, Berlin, Brandenburg, Baden-Württemberg, Hesse and Rhineland-Palatinate with shares all above 10 percent. Baden-Württemberg is the driving force of international exports, not in terms of relative but absolute importance, with an amount of 24.9 Bn. € in 2011. This corresponds to a 30 percent share of overall exports of the German health economy. North Rhine-Westphalia and Bavaria follow with 13.1 and 11.1 Bn. €. Adding Hesse with corresponding 9.4 Bn. € in fourth place, the overall export amount of named federal states corresponds to around 70 percent of overall German exports of the health economy.

Figure 6: International export share of the health economy, 2011

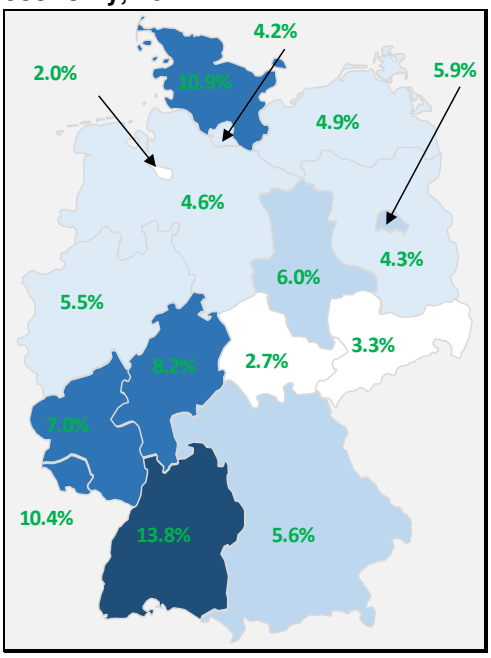


Source: own illustration based on BMWi (2017b).

[3] The definition of industrially characterized categories can be retrieved from BMWi (2017a).

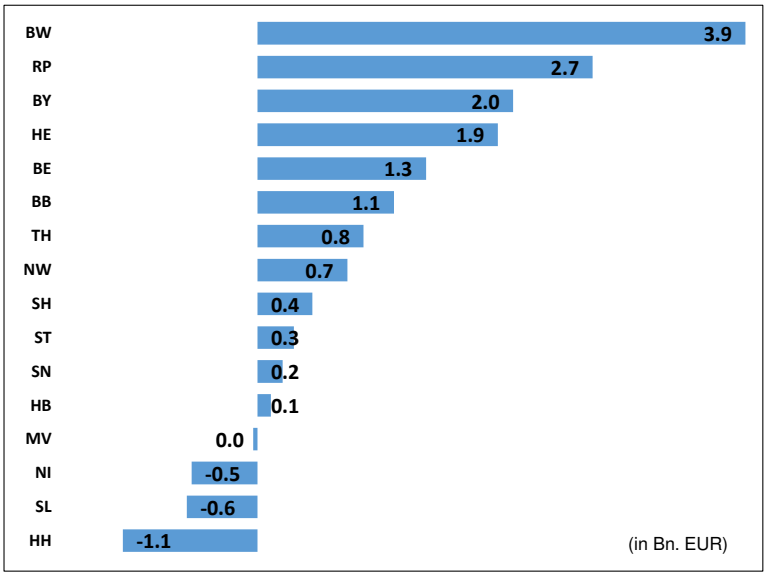
A high amount of exports often entails a similar characteristic regarding imports in the sense of mutual transfer of knowledge. International collaboration and cross-national manufacturing processes are essential characteristics of the health economy. Depicting the import share of the health economy therefore shows a similar scheme as the previous figure. Compared to the overall German health economy import share of 6.9 percent in 2011, the federal states Baden-Württemberg, Schleswig-Holstein, Saarland, Hesse and Rhineland-Palatinate show an above average relevance of this cross-sectoral industry for overall import activities. Named federal states are responsible for more than half of overall imports of the German health economy. On average, medication makes up about 50 percent of imports of the health economy. Baden-Württemberg, however, is characterized by a 70 percent share of imports reflected by medication. Influence of medication products on the national health economy is high in this context. About 45 percent of overall medication imports corresponds to Baden-Württemberg. Its export share is only slightly lower. This circumstance reflects the special role of Baden-Württemberg as an important supplier and international trading partner for medication. However, it is interesting to see in this matter that the importance of Baden-Württemberg is outperformed by Hesse when we look at medication output. We hence can conclude that there are different focusses and manufacturing processes applying when it comes to the supply of medication. We will look at this circumstance in subsection 3.2 in order to see whether the modelled characteristics of the health economy apply in reality.

Figure 7: Import share of the health economy, 2011



Source: own illustration based on BMWi (2017b).

Figure 8: International trade balance of the health economy, 2011



Source: own illustration based on BMWi (2017b).

The external trade balance of the German health economy amounts to 13.2 Bn. € in 2011. Opposing it to the overall German external trade balance results in a ratio of 10 percent, the health economy contributes to the overall characteristic. With the exception of Hamburg, Saarland, Lower-Saxony and Mecklenburg Western Pomerania, all other federal states show a positive trade balance from international activities in the context of the health economy. The highest contribution goes back to Baden-Württemberg with 3.9 bn. € external trade balance, followed by Rhineland-Palatinate, Bavaria and Hesse, which all show a similarly high degree of importance regarding output of industrially manufactured health products.

3.2 Characteristics of medication supply in German federal states in 2011

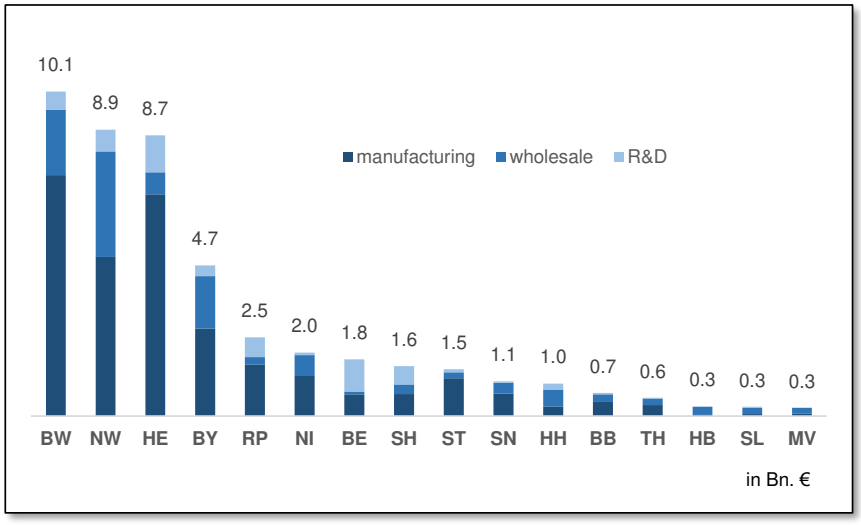
In the previous subsection, we looked at the results of the overall health economy in German federal states for 2011 in order to establish a big picture regarding intention and use of the model. This subsection concentrates on figures in the context of medication supply exclusively in order to conclude upon the reasonability of results.

One advantage of this focus is we can challenge the MRHA results with information on operating companies. Moreover, manufacturing industries show a much more diverse structure in auxiliary production compared to service-oriented industries. This means that obtained product-specific information differs from given industry-specific information to a larger amount compared to i.e. the industry of health services, which exhibits hardly any auxiliary production. Hence, we expect to obtain the best impression regarding the reliability of the model if we look at product-specific output related to industrial production, which is accordingly supposed to differ from given industry-specific information to a higher extent.

The product-specific approach we pursue in the context of the satellite account implies we look at medication for human use only, regardless of the question by which industry it is produced. Moreover, we do not consider any other output of the involved industries, which is not directly related to human health, e.g. chemical or veterinary products. Hence, we refer to this as 'medication'. The product-specific approach also implies that we are able to define certain additional categories in the satellite account, including the differentiation between manufacturing, R&D and wholesale in the context of medication. Therefore, we are able to analyze the defined different categories of the health economy in terms of output, GVA, export and import. Schwärzler & Kronenberg (2017a) provide an overview of all categories of the health economy.

Since we have now discussed the object of further investigation, we look at the different characteristics of medication supply in the context of the MRHA. We distinguish between manufacturing, wholesale and R&D. In order to get a sense of the reliability of the elaborated approach, we look at the respective characteristics of federal states to see whether we can find any explanations in additional secondary data, which were not included in the compilation of the model.

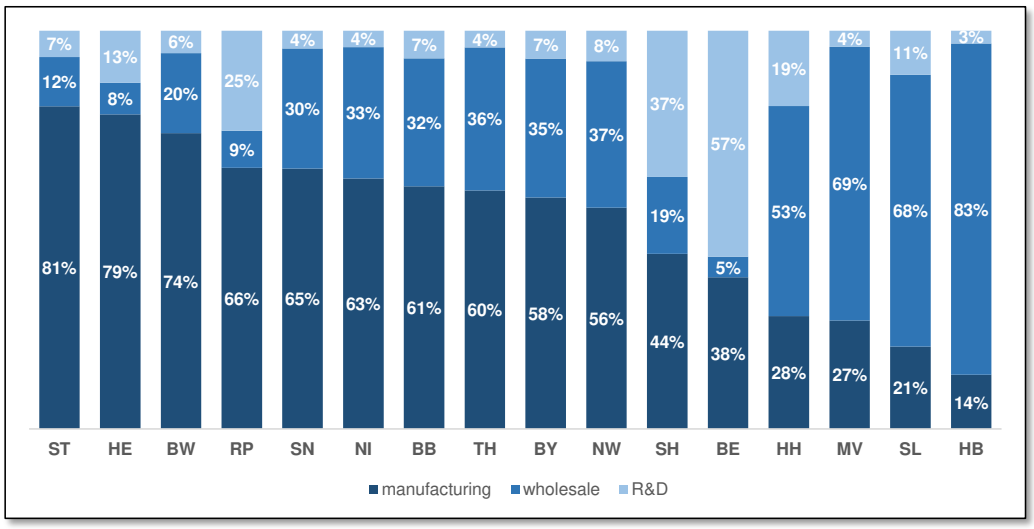
Figure 9: Output of medication in German federal states by characteristic, absolute values, 2011



Source: own illustration based on BMWi (2017b).

In order to proceed accordingly, we focus on some federal states, which show specific characteristics and for which secondary information is available. Hence, we hypothesize that in reality and hence according to the results of the MRHA shown in Figure 9 and Figure 10, Hesse, Saxony-Anhalt and Baden-Württemberg exhibit high amounts of manufacturing activities, North Rhine-Westphalia and Bavaria are characterized by larger shares of distribution and Berlin, Rhineland-Palatinate and Schleswig-Holstein represent important locations for R&D activities.

Figure 10: Output of medication in German federal states by characteristic, relative shares, 2011



Source: own illustration based on BMWi (2017b).

Figure 18 in the appendix contains information on the name and focus of active companies in German federal states. However, we want to point out that this information does not provide a complete picture of operating companies, since the map focusses on companies conducting R&D. Hence, companies performing e.g. wholesale or manufacturing exclusively are not represented in this figure. In order to make the amount of included information manageable, we compiled a summary of represented information, putting emphases on selected pharmaceutical industries only, in Table 1. We decided upon their relevance by referring to the top ten companies, which generate the highest revenue in Germany on the one hand (IMS Health, 2015) and on known German brands on the other hand.

Large crosses indicate a high relevance of the operating company in the federal state in terms of employees, whereas small crosses indicate a lower relevance. We do not provide exact numbers, since the quality of referring data base and the period in consideration differ among companies. Moreover, we are not able to distinguish between the subsidiaries of companies in terms of employees. Hence, the table aims at providing an overview and an initial assessment of operating countries only.

Table 1: Sites and subsidiaries of selected pharmaceutical companies

	(Research)/ preclinical development	Clinical development	Distribution & shipping	API production	Production of finished pharmaceuticals
BW					
BY					
BE					
HE					
NW					
RP					
SH					
ST					

AbbVie	Allergo-pharma	Astra Zeneca	Bayer	Berlin-Chemie	Boehringer Ingelheim	GlaxoSmithKline	Lilly Pharma	Merck	Novartis	Pfizer	Roche	Sanofi

Source: own illustration based on vfa (2015).

First, we take a closer look at federal states with above-average activities in manufacturing, which is Hesse, Saxony-Anhalt and Baden-Württemberg, according to our results.

In Hesse, Sanofi-Aventis Deutschland GmbH and Merck KGaA mostly shape this characteristic since both have manufacturing sites located here. Sanofi-Aventis Deutschland GmbH employs about 7,300 people in Hesse, performing manufacturing, R&D and administration over there. Distribution is carried out by about 1,100 employees in Berlin (Sanofi-Aventis Deutschland GmbH, 2017a). Moreover, the Sanofi-Aventis Deutschland GmbH site in Hesse is one of the most important locations for manufacturing of the overall and worldwide operating Sanofi-Group (Sanofi-Aventis Deutschland GmbH, 2017b). Merck KGaA in Hesse does not reveal specific numbers. They employ about 10,900 people in overall Germany in all sections, including business in pharmaceuticals, chemicals, life science and material science. Hence, the number of employed people applying to the considered case is probably reasonable lower, since about 40 percent of worldwide sales originate from the chemical division in 2011 (Merck KGaA, 2012a). Nevertheless, Merck KGaA carries out production next to distribution, R&D and administration in Hesse. Moreover, we know that Merck KGaA increased their tablet production from four billion to eleven billion tablets during the period 2003 to 2011 (Merck KGaA, 2012b).

Baden-Württemberg also shows a strong focus on manufacturing, similarly to Hesse. The most influencing company over here is Boehringer Ingelheim GmbH with about 5,500 employees (Boehringer Ingelheim GmbH, 2015). This company owns one of the largest manufacturing plants worldwide and puts emphasis

on R&D at this site. Pfizer Deutschland GmbH contributes about 1,000 employees exclusively to manufacturing and 100 employees to distribution (Pfizer Deutschland GmbH, 2017b; Südwest Presse, 2012), while Roche Pharma AG focusses merely on marketing, sales and R&D with 1,200 employees in Baden-Württemberg (Roche Pharma AG, 2017).

Saxony-Anhalt shows the greatest share of manufacturing among all federal states. Over there, Bayer HealthCare AG produces Aspirin® in one of the biggest sites worldwide in this context, employing about 350 people (Bayer AG, 2015). Moreover, additional data sources reveal activities of Novartis with about 1,500 employees working on manufacturing and distribution in Saxony-Anhalt (DIW, 2015; Salutas Pharma GmbH, 2015).

We hence can conclude that the relatively large share of manufacturing in Hesse, Baden-Württemberg and Saxony-Anhalt resulting from the MRHA is reasonable due to the existence of large production sites in each of the federal states, without showing any contradictory information on different emphases.

In the following, we take a closer look at federal states particularly characterized by distribution activities of medication, North Rhine-Westphalia and Bavaria amongst them. The first is dominated by the activities of the company Bayer HealthCare AG employing about 13,000 people. Novartis is the main contributor to activities in Bavaria with having about 4,000 people employed in the context of medication. However, neither of these companies exhibit distribution and shipping activities according to vfa (2015), which contradicts our results. Unfortunately, this is caused by the focus on companies dedicated to R&D on the map.

However, according to DIW (2015), two reasonably large sites of Novartis AG conduct distribution of medication next to development, manufacturing, marketing and R&D of medication. Each of the sites employs about 2,000 people. However, the main production facility of Novartis AG is located in Baden-Württemberg. In the case of North Rhine-Westphalia we discover the high relevance of Bayer Vital GmbH, which is the distribution company of Bayer HealthCare AG, employing 1,700 people (Bund-Verlag, 2011). Moreover, additional distribution activities are conducted by relatively smaller companies such as Janssen-Cilag GmbH and Grünenthal GmbH in North Rhine-Westphalia, employing an overall amount of about 800 and 1,800 people in this federal state (Janssen-Cilag GmbH, 2017; Grünenthal GmbH, 2017). In conclusion, a higher focus on distribution compared to the federal states aforementioned is reasonable, since both main contributing companies in these federal states, Novartis AG and Bayer HealthCare AG, conduct a reasonable amount of wholesale activities over there.

In the case of R&D, we find above-average shares for Berlin, Schleswig-Holstein and Rhineland-Palatinate. Since overall output of medication is reasonable lower in these federal states compared to the ones already described, the amount of available information is accordingly less, especially in the case of Rhineland-Palatinate and Schleswig-Holstein.

We suggest that the strong impact of Boehringer Ingelheim GmbH with an above-average R&D intensity of 13.4 percent (Boehringer Ingelheim GmbH, 2015) compared to overall German pharmaceutical industries has a high impact on this characteristic for Rhineland-Palatinate.

AstraZeneca GmbH operates in Schleswig-Holstein, conducting R&D in addition to manufacturing and marketing with about 800 employed people (AstraZeneca GmbH, 2015). The company is known for its high investments in R&D, resulting in an overall R&D intensity of around 16.5 percent, which is reasonable well

above the German average (AstraZeneca GmbH, 2012). Another company operating and participating in R&D in Schleswig-Holstein is Allergopharma GmbH & Co. KG, a subsidiary of Merck KGaA with about 480 employees of which 12.5 percent are dedicated in R&D (Allergopharma GmbH & Co. KG, 2014).

Last, but not least, Berlin shows the highest share of R&D activities among all German federal states. Manufacturing is only conducted by the companies Bayer HealthCare AG and Berlin-Chemie AG. The first employs about 4,900 people in Berlin but conducts manufacturing activities to a considerably low amount only. This is due to the fact that this location is one out of four main sites for R&D of Bayer HealthCare AG worldwide. Therefore, the Berlin site focusses on R&D in particular (Bayer AG, 2011&2017). Berlin-Chemie AG employs about 1,800 people in Berlin, about 400 among them focusing on research and development (Berlin-Chemie AG, 2017). Moreover, Pfizer Deutschland GmbH and Sanofi-Aventis Deutschland GmbH have sites in Berlin as well, employing about 650 and 1,100 people. Pfizer Deutschland GmbH focusses on R&D, administration and marketing (Pfizer Deutschland GmbH, 2017a), while Sanofi-Aventis Deutschland GmbH conducts marketing and distribution over there (Sanofi-Aventis Deutschland GmbH, 2017a). Putting together all this information, we can indeed obtain a focus on R&D in the three federal states Berlin, Schleswig-Holstein and Rhineland-Palatinate, supporting our MRHA results.

Summarizing, we managed to find reasonable qualitative information that support our findings of the MRHA regarding direct effects of manufacturing, wholesale and R&D activities in the context of medication supply. In the following, we look at overall time series results of the MRHA in a first step and see whether we can find reasonable explanations for obtained developments in a second step.

4 Direct effects of the health economy during the period 2006 to 2015

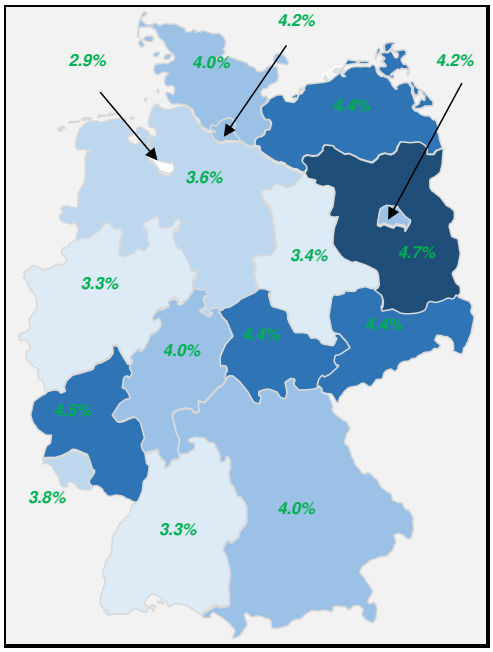
While we focused on MRHA results for the year 2011 in section 3, we look at the development of key figures during the period of 2006 to 2015 in this section. In general, the elaborated MR-SUT-RAS can be applied to calculate multiregional supply and use tables for several different years. However, we are well aware of the fact that we move along a small ridge between methodological appropriateness and technical feasibility in this case. This is the reason we do not focus on the application of the algorithm in a time series in general. We want to demonstrate its performance in this matter nevertheless, since it provides a good opportunity to look at the reliability of the approach from a different perspective.

Therefore, we describe the results on the overall health economy in German federal states during the period 2006 to 2015 in order to enable a basic understanding of use and aim of this application in subsection 4.1. In subsection 4.2 we continue with a special focus on the supply of medication similarly to subsection 3.2. Instead of focusing on just one year we look at the modelled dynamics over time again. We challenge obtained results with industry specific information and company data in order to question their consistency with reality. Again, the overall goal is to develop an assessment concerning the validity of the elaborated approach.

4.1 The overall health economy in the German federal states during 2006 to 2015

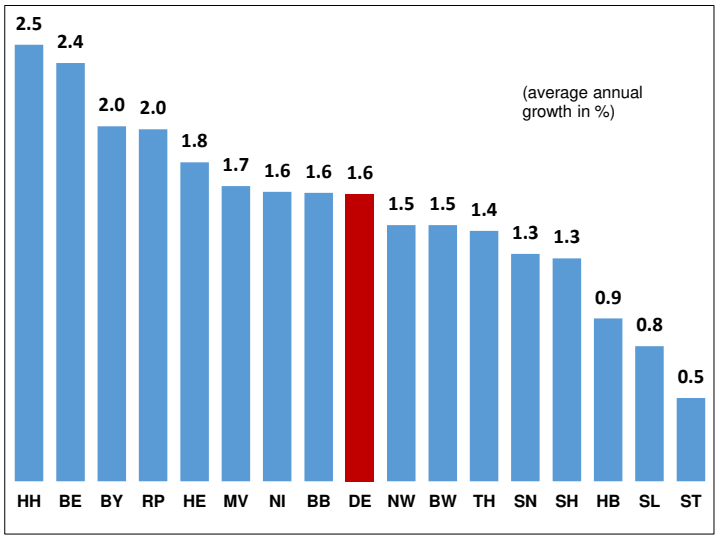
The GVA average annual growth rate of the German health economy amounts to 3.8 percent in nominal terms during the period 2006 to 2015. If we compare this indicator to the overall economic development we find a higher growth rate for the health economy to the extent of 0.8 percentage points. In German federal states, growth rates of the health economy range between 4.7 percent in Brandenburg and 2.9 percent in Bremen. At this point, it is worth noting that the health economy grew faster than the overall economy in all federal states (VGRdL, 2016), even in those with the lowest GVA growth rates of the health economy. Moreover, the federal states Hamburg, Rhineland-Palatinate and Saarland show the greatest positive gap between the growth rates of the health economy and the overall economy. In those regions, the dynamic of the health economy tops the overall economic development by about 2.0 percentage points. In Hamburg, this development is driven by the largest increase in health expenditures among all federal states in the same period of time. This way, the sector outperforms the city state's overall economic development. Brandenburg, the federal state with the highest GVA growth rate, exhibits about 60 percent of overall increase from inpatient and outpatient treatment. Moreover, supply of medication increased in Brandenburg in terms of manufacturing, wholesale and R&D activities from nearly non-existent to about 0.6 Bn. € in 2015.

Figure 11: GVA growth rates of the health economy, 2006-2015



Source: BMWi (2017b).

Figure 12: Employment growth rates of the health economy, 2006-2015



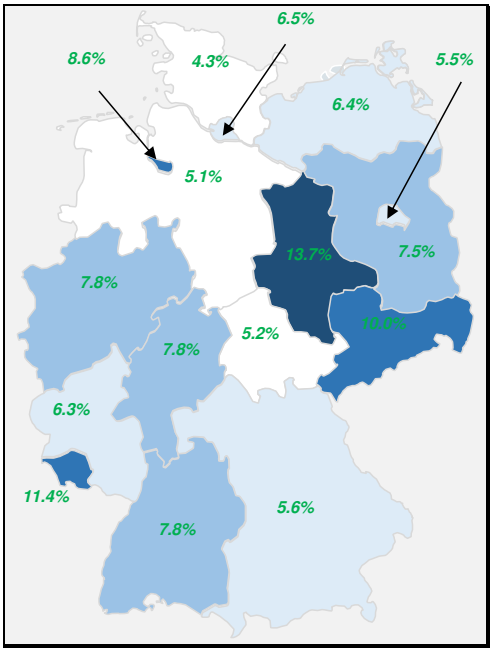
Source: BMWi (2017b).

The heterogeneous composition of the health economy is responsible for the different picture employment growth rates of this cross-sectoral industry show in contrast to GVA growth rates. Hamburg, Berlin, Bavaria and Rhineland-Palatine exhibit the highest growth rates for the period 2006 to 2015 among all federal states. A high increase of employees in the context of inpatient and outpatient treatment causes this development in Hamburg and Bavaria. The very same indicator, however, shows only below-average values for Berlin and Rhineland-Palatine. In Berlin, R&D activities of the health economy are driving forces of increasing employment, due to both high significance and above-average growth rates of this area. In Rhineland-Palatine, employment growth in the context of both, health tourism and supply of organic food, stimulate the development of the overall health economy. Hence, we

observe a great variety in determining factors of economic dynamic in the case of the health economy. This example points out the advantage of the MRHA very clearly, since it provides additional information on the development of the health economy in contrary to the NHA, which lacks regional diversification.

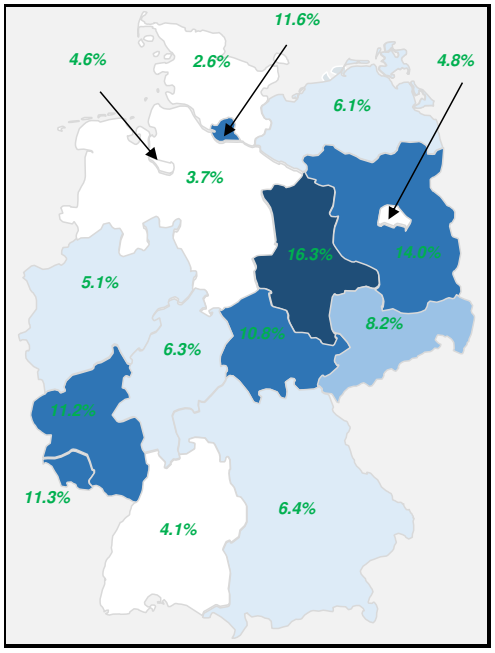
Export of products and services of the German health economy increased by on average 7.1 percent per annum between 2006 and 2015. Hence, the health economy shows a substantial above average growth of exports, which is 2.9 percentage points higher than the export growth rate of the overall German economy. This indicator differs vastly among federal states. The highest growth rate is observed in Saxony-Anhalt, where exports of the health economy increased by on average 13.7 percent per annum since 2006. This corresponds to a rise from 700 m. € in 2006 to 2.3 bn. € in 2015. About three-quarters of this increase result from export activities in the context of medication. The most significant growth in absolute values is recorded in Baden-Württemberg. Exports went up by 16.6 bn. € between the years 2006 and 2015. This in turn implies that the health economy of this federal state is responsible for about one third of German increase of exports in the field of the health economy.

Figure 13: Export growth rates of the health economy, 2006-2015



Source: BMWi (2017b).

Figure 14: Import growth rates of the health economy, 2006-2015



Source: BMWi (2017b).

Imports of the German health economy increased by on average 6.0 percent per annum in the period 2006 to 2015. They hence show a lower dynamic compared to exports in this field. This caused the German external trading balance of products and services of the health economy to increase in that period of time. Similar to exports of the health economy, imports rose to a higher extent compared to overall German imports, resulting in a positive gap of 2.3 percentage points. Again, we recognize similarities between imports and exports in regional characteristics. Saxony-Anhalt shows the highest increase in imports of the health economy to the amount of on average 16.3 percent per annum. This corresponds to an absolute increase of imports of 1.4 Bn. € since 2006. Although international trade of the health economy in Saxony-Anhalt generates a positive external trade balance, this could change in the future, if imports remain to show higher growth rates than exports.

4.2 Characteristics of medication supply in German federal states 2006 - 2015

After we have provided an overview of MRHA results for the period 2006 to 2015 in subsection 4.1, we proceed with a detailed analysis similarly to subsection 3.2. However, instead of looking at characteristics for one specific year, we focus on the time series development of key indicators in this subsection. We proceed accordingly, since we want to verify that the elaborated approach exhibits reasonable results also in a time series framework. Hence, this analysis is a further step to challenge the reliability of the developed approach. According to subsection 3.2, we concentrate on the supply of medication for the same reasons provided over there.

In the following, we focus on results from two different federal states. First, we take a closer look at Berlin, which exhibits a strong and increasing focus on R&D, while only two companies are involved in manufacturing. Second, we examine results in North Rhine-Westphalia. This federal state is second in the overall amount of medication supply among German federal states. From subsection 3.2 we know that this characteristic is dominated by one main company. This circumstance favors a detailed analysis since we expect to find a direct link between company data and obtained results. Therefore, the two federal states show certain characteristics we pursue to identify in the following, both in results and secondary data.

In order to proceed accordingly, it is not conducive to make use of official statistics regarding the pharmaceutical industry. Official statistics do not account all companies, a common industry representative would assign to the statistical entity of a pharmaceutical industry, as such. For example, the companies Pfizer Deutschland GmbH and Sanofi-Aventis Deutschland GmbH, each of them employing more than 1,000 people in Berlin are accounted as trading companies in official statistics, since they do not manufacture any pharmaceutical products in this federal state. Consequently, neither their employees nor their sales are represented by the indicators of the pharmaceutical industry from official statistics. The same applies to Teva GmbH, Takeda Pharma Vertrieb GmbH & Co. KG and Parexel International GmbH next to some other service companies (Pharmahauptstadt Berlin, 2017).

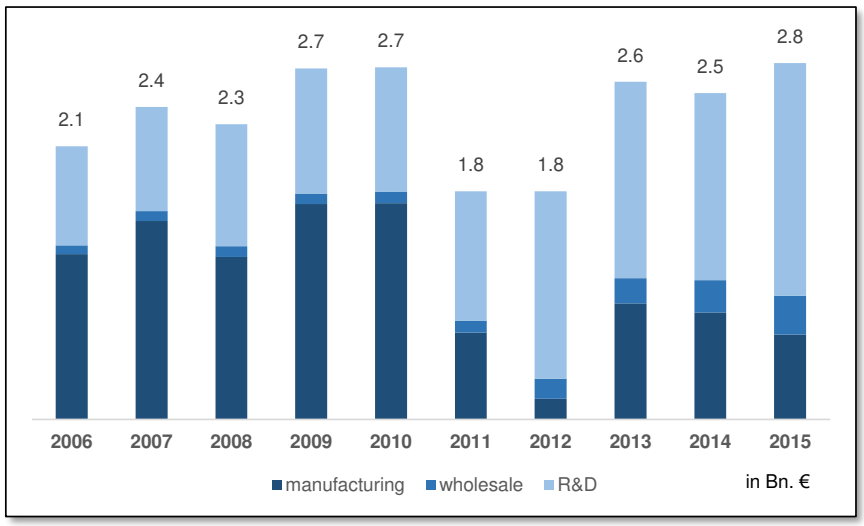
This is the reason why our satellite account does not focus on industry-related but on product-specific data. Hence, we include and separate from each other manufacturing, wholesale and R&D of medication, independently from the fact which industry it produced.

Figure 15 exhibits the results from our model for Berlin, focusing on output of medication in terms of the three named categories for the period 2006 to 2015. As already depicted in subsection 3.2, there is a clear focus on R&D, which is in addition growing in relative and absolute importance. Moreover, manufacturing activities declined and show their lowest amount in the years 2011 and 2012.

The existent and growing importance of R&D can be confirmed by secondary data. In general, there is an overall increase in R&D of German pharmaceutical companies (vfa & Stifterverband, 2016). Moreover, Pfizer Deutschland GmbH has settled in Berlin in the year 2008. This site focuses on R&D next to HR, finance, market access, communication and marketing. Manufacturing and wholesale are both carried out in Baden-Württemberg (Pfizer Deutschland GmbH, 2017b). Hence, some of the increases in R&D are certainly attributable to the company Pfizer Deutschland GmbH. Moreover, Bayer HealthCare AG as the biggest company in Berlin with about 4,900 employees, raised its overall expenditures on R&D by on average about 8 percent per annum since 2006 (Bayer AG, 2007&2016). We argue that this has impact on R&D

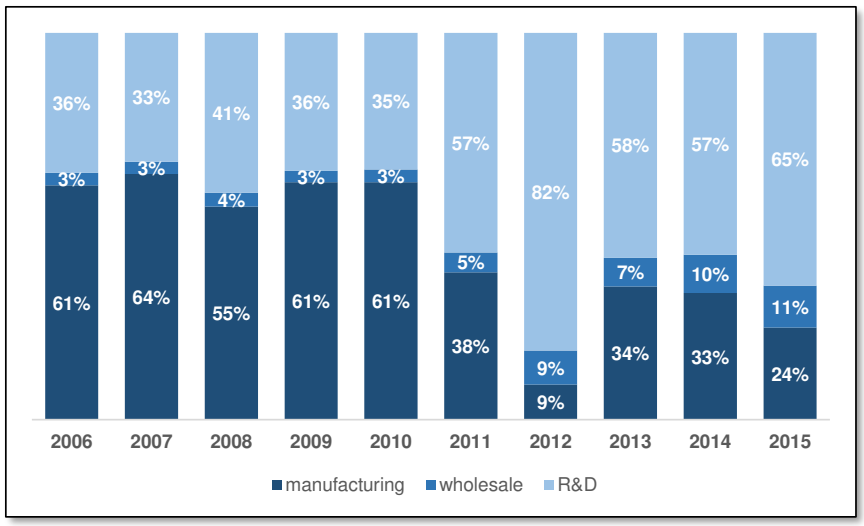
output in Berlin, since one of Bayer HealthCare AG's worldwide four sites on R&D is located in this federal state (Bayer AG, 2016).

Figure 15: Output of medication in Berlin by characteristic, absolute values, 2006-2015



Source: own illustration based on BMWi (2017b).

Figure 16: Output of medication in Berlin by characteristic, relative values, 2006-2015



Source: own illustration based on BMWi (2017b).

The second circumstance Figure 15 exhibits, is a decrease in manufacturing in the years 2011 and 2012, followed by an increase in the years afterwards. Nonetheless, output did not catch up with amounts of output from 2010. Moreover, we can see an absolute and relative increase in wholesale from 2013 on. In the following, we will try to explain this development with information from secondary data.

In Berlin, there are only two main companies involved in manufacturing of medication – Bayer HealthCare AG and Berlin-Chemie AG. Since the first shows about the fourfold of employees compared to the latter, we will focus on the development of the first in order to explain the dynamics from reality.

According to qualitative data sources, the year 2010 was challenging for the pharmaceutical industry, due to cost reductions of health systems all over the world and increased competition from generic drugs. Moreover, demand of the contraceptive pill group YAZ™, Yasmin™ and Yasminelle™, which brought Bayer HealthCare AG revenues to the amount of 1.2 Bn. € in 2009, weakened in a double-digit range (WiWo, 2010; Der Tagesspiegel, 2011). This impacted on the Berlin site, since packaging of these products is one main focus of manufacturing at this location. While these activities were carried out by several extra shifts of employees in Berlin in the years before, decreased demand resulted in a reduction of shifts and output by a quarter (Der Tagesspiegel, 2009). At the same time, Bayer HealthCare AG announced to reduce employees in Germany by 700 people. All this happened in the course of reorganization aiming at investing more in R&D and reducing costs in administration. It was seen to be very likely that the site of Berlin was highly affected by the reduction in employment, since the decrease in demand of the names contraceptive pills had high impacts on the production site (WiWo, 2010). Reorganization was said to incur costs at the amount of 1 Bn. €, but supposed to save 800 m. € on a yearly basis from 2013 on (Der Tagesspiegel, 2011).

In a retrospective review, the years 2009 until 2011 were characterized by strict cost management (Berliner Zeitung, 2014). From 2012 on, Bayer HealthCare AG was back on the path to growth and experienced a record year in 2013. Simultaneously, Bayer HealthCare AG increased expenditures on R&D favoring the site of Berlin, according to a manager of Bayer HealthCare AG in 2014. The upward trend is also supported by a contract between Bayer HealthCare AG and the labor union IG BCE, which prohibits Bayer HealthCare AG from compulsory redundancies until 2020. The contract is aiming at strengthening the location and ensuring R&D activities in Germany (Der Tagesspiegel, 2016).

According to what has just been described, we conclude that the reduction in manufacturing in Berlin shown in Figure 15 is reasonable due to the decrease in demand of Bayer Health Care AG's contraceptive pills, an overall reduction in costs and a reorganization of the company. The depicted increase in R&D can also be explained.

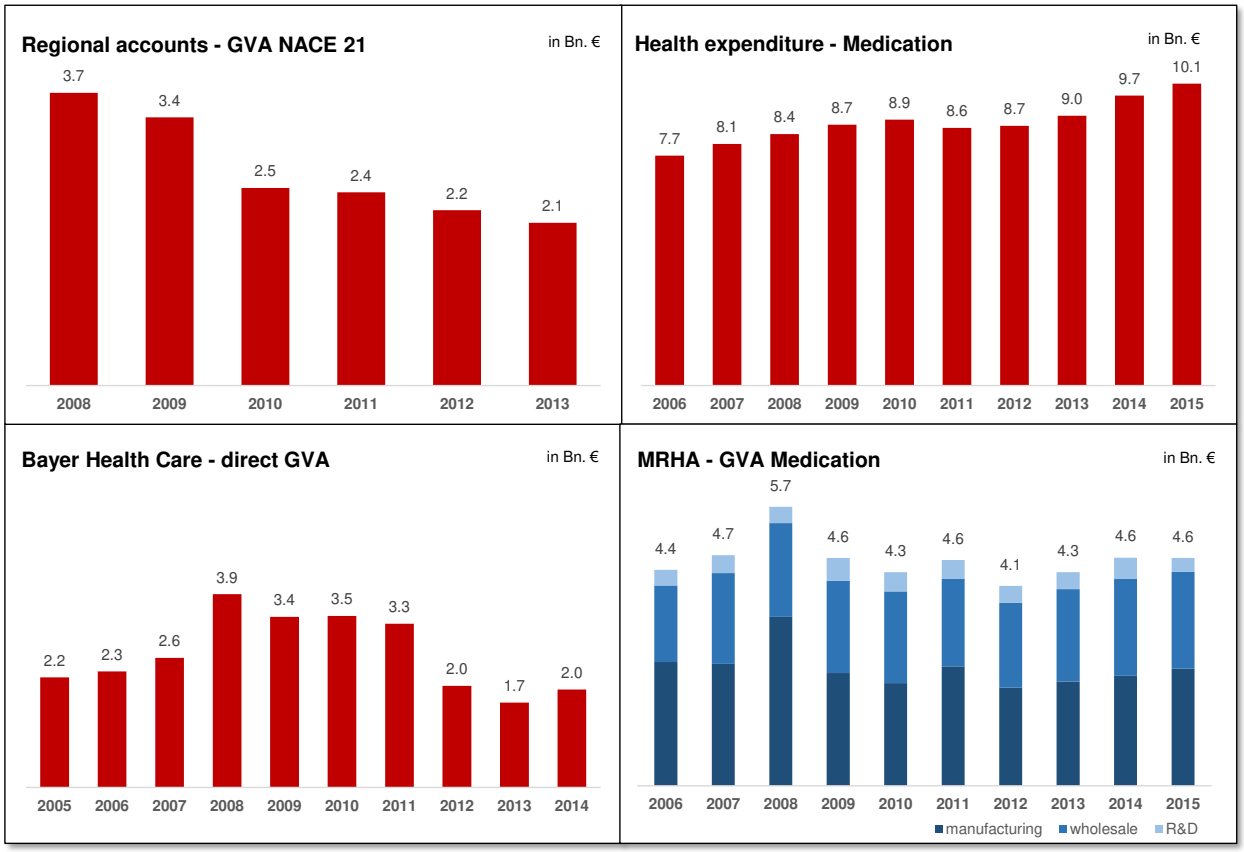
In a next step, we take a closer look at dynamics of medication supply in North Rhine-Westphalia. The right box at the bottom of Figure 17 depicts corresponding GVA according to the MRHA. We observe a dynamic development, which is caused by a high amount of GVA from manufacturing in 2008, decreasing to a lower level with sudden drops in the years 2009 and 2012, which is again followed by an increase in GVA from 2013 on. In the following, we look for secondary data supporting these results.

Medication supply in North Rhine-Westphalia is mainly dominated by the company Bayer HealthCare AG. Hence, we do not necessarily have to look at a large number of different companies in order to observe a first guess regarding the reliability of the MRHA. Moreover, since we have just looked at Bayer HealthCare AG's site in Berlin, it should be clear so far that not all of the company's dynamics are reflected in medication output of North Rhine-Westphalia. However, the largest share of activities indeed goes back to this federal state since about two thirds of Bayer HealthCare AG's employed people in Germany work at the several sites in North Rhine-Westphalia.

We observe the great opportunity to have data on direct GVA of Bayer HealthCare AG available from a completely unrelated earlier project (Ostwald et al., 2016). This data, shown in the left bottom box of Figure

17, was not incorporated into the MRHA in any way. Therefore, we matched results from the MRHA and GVA of Bayer HealthCare AG for the cause of validation. The level of GVA is a different one due to inaccuracies in the context of the regional differentiation of operating companies involved. This applies to the case of Bayer HealthCare AG itself, as described above, but also to other – reasonably smaller - companies active in North Rhine-Westphalia, such as Janssen-Cilag GmbH, Grünenthal GmbH or Baxter Deutschland GmbH. In addition, results obviously derive from different approaches. The one relies on regional data from national accounts, while the other calculates results from primary company data.

Figure 17: Comparison of MRHA results with related secondary data in the field of medication.



Source: VGRdL (2016); Ostwald et al. (2016); own illustration based on BMWi (2017b).

Ignoring the different levels of GVA, we recognize a similar dynamic when we compare results from the MRHA with Bayer HealthCare AG GVA. Both show peaks in 2008 followed by a decrease in GVA to a reasonable lower level in the period 2009 to 2011 and a further significant drop in 2012. Increase in GVA starts in 2013 according to MRHA results opposed by an increase of Bayer HealthCare AG GVA in 2014. However, both data show a general upward trend in the recent years. We hence conclude that the dynamic of medication supply resulting from the MRHA is reasonable.

In a next step, we look at secondary data we implemented in order to the compile the MRHA. First, we focus on GVA of NACE 21 from official regional accounts (VGRdL, 2016), referring to the pharmaceutical industry Bayer HealthCare AG also belongs to. This data exhibits a clear decrease of GVA for the overall available period of 2008 to 2013 including an instant drop in 2010. Official response to this matter revealed a re-classification of one important player from NACE 21 to NACE 20 in 2010, the latter referring to the chemical industry. Since industry-specific GVA clearly represents essential information applied to the MR-

SUT-RAS, we find it convincing regarding the reliability of the approach that we do not observe any similar development from MRHA results. Even more, it is a good indicator of quality that similarities of MRHA results are closer to GVA of Bayer HealthCare AG than to regional accounts.

In a further step, we look at data from regional health expenditure (BMWi, 2017b[4]), which is another secondary data source we implemented into the model. With the exemption of 2011 and 2012, expenditures on medication continuously increase. Hence, we do not recognize any implausible direct influence of this closely related and implemented data on the results of the MRHA again.

From subsection 4.2 we conclude that the MR-SUT-RAS leads to reasonable results even if we apply it to several years. This applies to Berlin as well as to North Rhine-Westphalia, while the latter offers the great opportunity to match results with available company data.

5 Concluding remarks

This paper aims to challenge results from the MRHA with secondary data in order to conclude on the reliability of the elaborated approach. We find that the compiled figures deliver reasonable results in both evaluated dimensions.

First, we discover that provided economic key figures on the health economy for 2011 reproduce specific characteristics of federal states obtained from independent secondary information. We performed this analysis in the context of medication, since industries involved in production are characterized by a reasonable amount of auxiliary production. Hence, we expect significant differences between given industry-specific and modelled product-specific information. We find that the multiregional supply table obtained from the developed approach exhibits essential characteristics, which allow a federal state specific differentiation between manufacturing, wholesale and R&D in the context of medication. Qualitative secondary data indicate the reliability of derived characteristics.

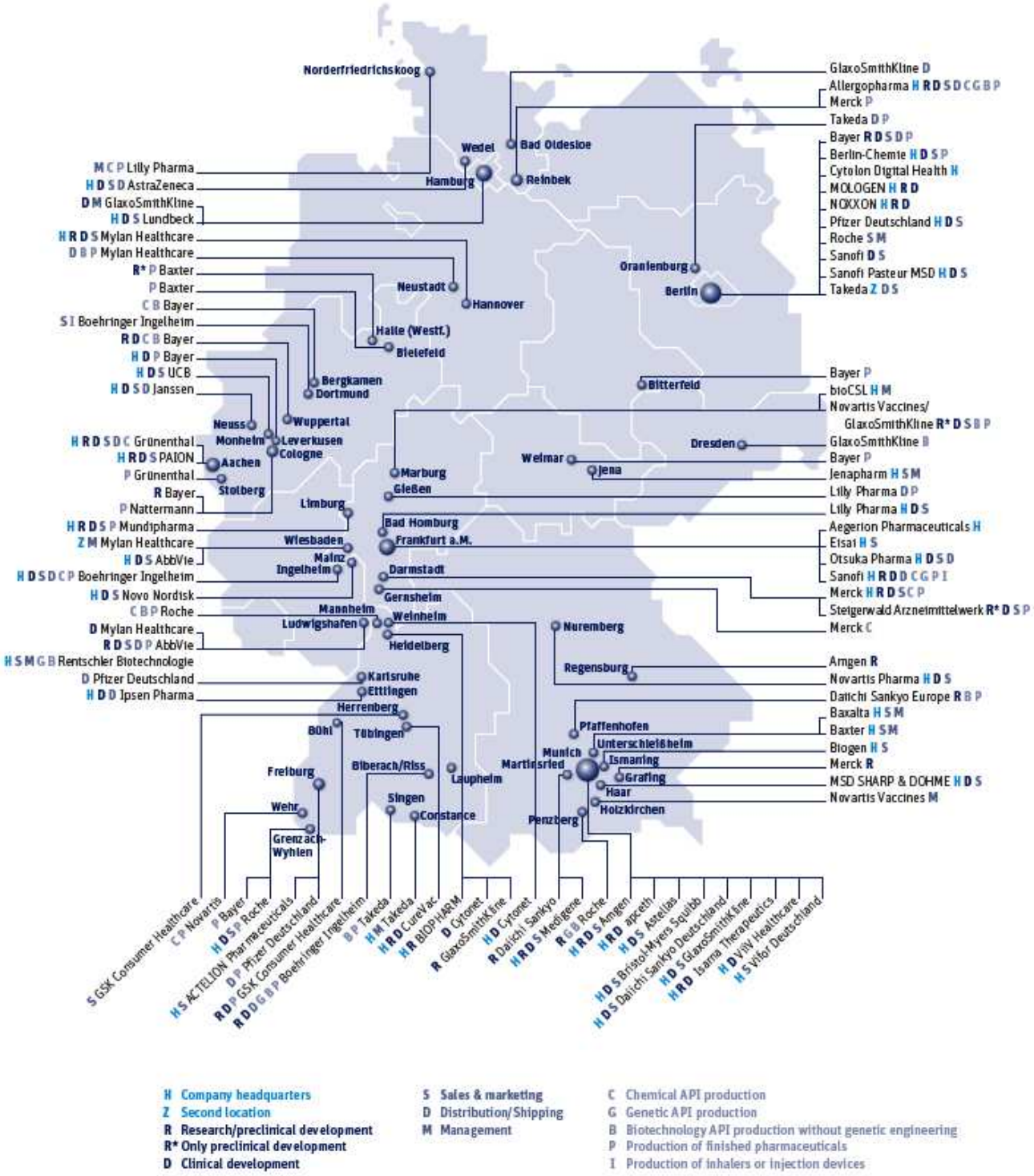
Second, we applied the model in a time series to examine the performance of the MR-SUT-RAS and its application in the context of health, the MRHA, for different data sets. We perform this application for ten years based on the only two tables of national accounts available for 2010 and 2011. Obtained results show that the model is capable of approximately reproducing specific company data. This comparison is possible due to the fact that the company of concern is responsible for the clear majority of activities in the evaluated federal state. This finding is a convincing argument for the reliability of the developed approach particularly in regard of the fact that generic national tables were not available for all of the considered years.

Hence, despite the absence of official supply and use tables for the German federal states, we managed to challenge product-specific satellite account information of the health economy with secondary data. We find that the elaborated approach to compile the MRHA manages to reproduce certain characteristics of federal states in the context of the health economy not only for one specific year but also in a time series. We hence close this paper on validation of direct effects in order to look at indirect effects in the next step (Schwärzler & Kronenberg, 2017c). However, this procedure was essential to conduct in advance, since a valid data base in the context of product-specific output is essential for further input-output analysis.

[4] The calculation on regional health expenditure was conducted by our project partner BASYS in the course of BMWi (2017b).

6 Appendix

Figure 18: vfa member sites and their subsidiaries in 2015



Source: vfa (2015).

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