THE INTERNATIONAL DIVISION OF LABOR: FOOTLOSE TASKS AND PLACEBOUND WORKERS

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1. The challenge of a changing economic environment

The aim of this paper is to assess the effects of changes in the international division of labor on regional workforces. These changes are based on the evolution of globalization and smart production. We identify five factors as main driving forces of the recent and expected developments causing international trade and, thus, the economic environment to change worldwide. Technological progress in communication and transport advances (MÖLLER and WALWEI 2013: 133 ff.) due to rising investments in research and development in these segments (MEIL 2013: 122) is a first factor. New technological developments, as for example the 3D printer, which facilitate the production of product components independent of the production location, are closely connected to this first driving factor. As a second factor, we identify political decision and policy making in favor of a further liberalization of world trade, including treaties on free trade like TTIP or CETA. A third factor is that the region-specific growth of population leads to disparities in human capital endowment across regions leading to a brain drain with some regions expanding their trade-volume at the expense of regions with lower human capital endowment (ZIKA et al. 2014). Closely related to this is a fourth factor concerning the regional disparities in the endowment of goods and capital (MEIL 2013, ZIKA et al. 2014) with its own dynamics. The fifth identified factor is "containerization" of transporting and part-load traffic, leading to a more efficient trade. Smart Industry is a logical consequence of this.

These five trending factors urge industries to adjust their codes of conduct. Up to now strong, export-oriented branches (like construction of machinery, automobile and chemical industry) have internationally stood their ground with high quality products. However, competitive pressure will rise due to globalization inducing these industries to constantly defend their competitive advantage. Innovations in products and processes are going to be decisive, especially since value-added chains are increasingly complex and divided into small sections. Not only national borders are being crossed, but also (in some cases)highly specialized component suppliers have to be coordinated. Business conduct which has been popular in industrial production processes for a long time already will also grow in importance in other branches like trade and transport or agriculture due to population growth and urbanization. On limited space increasing amounts of food have to be produced, calling for increasingly efficient production techniques, while urbanization not only leads to higher spatial density but also poses challenges to trade and transport concerning the timely and constant allocation and supply of products and services. Individualization will lead to higher demand for individualized products. Shortage of resources also calls for optimized production processes. Together these processes will lead to continually increasing innovation, going hand in hand with increasing complexity and dynamics in value-added chains and calling for a rethinking of process-control in all branches. Organizational changes in operational sequences as well as intermediate production and changes in technical processes are also consequences of these developments.

The “Internet of Everything” (IoE) or Smart Industry will not only entail changes in product-control and planning but also profound changes at the labor market. The process of digitalization and automation of many production sections will, on the one hand, render a number of simple, routine jobs redundant. Besides, however, the profile of job requirements for all other workers will change substantially. Jobs will become more demanding and more non-formal qualification requirements will become decisive for recruitment strategies as for example the ability of acting independently and under their own responsibility, self-management or abstraction ability. On the other hand, new technologies, as for example 3D printers, enable the production of highly complex and sophisticated components which can be promoted directly to consumers and necessitate a relatively low input of high-qualified work.

Furthermore, a consequence of the cost reduction caused by increased usage of IoE technology is the relative cost advantage of, for example, products made in Germany. This could result in repatriation of offshored production processes, which in turn could reduce the imports of intermediate inputs. Since this would concern mainly simple, routine tasks, such a process would destroy jobs abroad and especially in countries with predominantly simple and routine jobs. (QUBE 2015)

Overall, the digitalization of the economy concerns all economic sectors and occupations (construction, logistics, trade, agriculture, healthcare etc.). However, this development will not eventuate in all sectors to the same extent or at the same time. In fact, it will likely be implemented especially in technical sectors which experience a high share of routine tasks (AUTOR 2014). Notwithstanding, the entire value chain of the economy will be affected. At first, the engineering sector (automation technology, process engineering, production technology) and the field of information technology and telecommunications (ITC) will be impacted including all related service industries, since especially these sectors are the main drivers in installing the necessary infrastructure for IoE (VERBAND DER ELEKTROTECHNIK 2013). There exists empirical evidence that IoE or Smart Industry will result in an increase of productivity of about 30%. First pilot studies, as for example conducted by Bosch in Homburg, Saarland, suggest that logistics will experience a growth in efficiency of about 10% (REFLEX-VERLAG 2014: 17). Furthermore, Germany in general would profit for IoE as a production location, since production in high-wage countries will gain in attractiveness.

The central question of this article is concerned with how and which jobs will change in structure and where these jobs will be located. So far, this question cannot be answered directly, since there is no empirical evidence yet of the development of Smart Industry in the economy itself.

This paper wishes to enhance the current literature as a tool set to describe the IoE process and its consequences for national and international labor markets. The paper is structured as follows. In section 2, we define a job by its composition of tasks and cognitive requirements and introduce theoretical frameworks to classify a job using these characteristics. Subsequently, using the example of the energy transition in Germany we show in section 3 how a changing economic context influences the occupation and qualification structure of a regional labor market. For this we first describe the data sources of the example analysis and, secondly, outline the operationalization and present first results. Building on this example, in section 4, we argue how regions face different adjustment procedures based on the international division of labor in response to a changing economic environment.

2. The change of task and cognitive requirements

“Which tasks have to be performed to produce xyz, and do they change or vanish due to changes in production processes?“ This question is mirrored by “In order to be able to do this, what qualification does an employee need to have?” Production here is actually divided into tasks, and workers perform these tasks at their workplace. They do so according to their skills and knowledge. Organizational changes or new products might then require the workers to perform different or new tasks, thus requiring new skills and knowledge. Economic research has started to closely examine these ‘tasks’ workers (have to) perform (AUTOR et al. 2003). They focus on explaining changes in shares of employment or wage growth due to changes in tasks, i.e. changes in the composition of qualification and skill demands. We are going to widen this focus and try to yield the full possibilities of tasks and skill requirements.

Theoretically and empirically the study is based on a combination of three frameworks. We need to examine requirements on the level of the working place: Firms structure their working places according to new requirements. Being able to describe occupational content and its links to new qualification demands puts us in a position to examine a) what the new requirements for firms and employees are and b) what their effect on the occupational structure is.

The first reference framework draws on work by PREDIGER et al. (c.f. PREDIGER/SWANEY 2004) who developed dimensions – namely „people vs. things“ and „data vs. ideas“ – which are used to describe certain aspects of occupational contents and for mapping occupations. The second framework assesses requirements on knowledge work by VOLKHOLZ/KÖCHLING (2001), where the working population is partitioned according to the type of knowledge work of their employment, ranging from qualified workers to task flexible and innovative workers. The third framework is the task-approach initiated by a paper from AUTOR et al.(2003) about the share of routine tasks of occupations, which is an enhancement of the “Skill-Biased Technological Change“. With these frameworks we can assess the characteristics of tasks, occupations, goods, and branches which determine their respective contents and thus tradability.

Originally developed within a project on impacts on qualification and skill demand within renewable energies, we combine three theoretical frameworks which all deal with occupational content but all have different perspectives on it. A job’s and also occupation's innovativeness correlates with the required type of knowledge work. Innovative employees often have to perform learning and creativity tasks[1].

VOLKHOLZ/KÖCHLING (2001) define these correlations and develop a typology of knowledge work. Since this framework actually allows us to describe innovative work with ideas, the second dimension of the world-of-work map (namely "data vs. ideas") is already incorporated. The map's other dimension, "people vs. things", shows a reference to working with objects, what is called "Objektbezug" in German. It may be translated to object-reference. Here it is differentiated whether you work with people (clients, patients, students) or with objects as in the production of (intermediate) goods. The reference frame of knowledge-work requirements sorts work-tasks according to the amount of knowledge-work required. Knowledge-wise you are a "routine worker" if all you do is apply the knowledge you have acquired. If you (sometimes) have to learn something new and relate it to what you already know, you are "task-flexible". If you do that (often) and also generate new knowledge, you are an "innovator". This dimension thus focuses on the cognitive side of work-tasks.

The dimensions of "people vs. things" and "data vs. ideas" serve to relate jobs and work-activities to each other. In the world-of-work map they are used to show relations of jobs and occupations which may be of interest for students to learn. The meaning of the poles include "impersonal processes" for data, "intrapersonal processes" for ideas, "interpersonal processes" for people and "non-personal processes" for things (PREDIGER/SWANEY 2004: 443). Here, all work processes are referred to in their relation to the person performing them. The dimension of "data vs. ideas" expresses the shares of tasks having to do with processing data and

[1]The term 'tasks' here refers to something broader compared to other author's definitions, i.e. the 'task-approach' or 'task-based technological change'. The German term 'Tätigkeit' allows for similar broad interpretations and thus both terms might lead to misunderstandings. Throughout this paper 'tasks' is refers to the more narrow definition of the task-approach literature.

handling information. These are either technical – as in managing data-bases or doing calculations –, or innovative – as in developing new ideas, be it alone or in communication with others.

AUTOR et al. (2003) analyze how tasks can be substituted or supplemented due to their routineness. Routineness is defined as the programmability of work tasks. If a task can be expressed in routines, which can themselves be programmed into a computer, they are more susceptible to substitution by machines or offshoring. At the same time widespread computer use has the effect of supplementing certain tasks. This leads to a polarization where routine tasks lose in significance, because fewer workers perform them and those who still do so experience wage penalties, while non-routine tasks gain in significance and more workers perform them while experiencing wage premiums – both in high-skill and low-skill segments. Routine tasks are more easily substituted and recruiting for occupations or jobs with these tasks is fundamentally different to recruitment for occupations dominated by non-routine tasks. AUTOR (2014:40) suggests that it is especially the routine tasks rather than high-qualification tasks which become substitutable in response to technology advancements.

Our combination of these three reference frames helps to better describe work tasks and occupational content. Tasks like „measuring, testing, controlling quality“ can have different meanings according to workplace conditions and requirements. The three frameworks here are seen as dimensions of a space in which occupational content in its different perspectives can be plotted. There is a dimension of routine, in the sense of programmability of work tasks. The second dimension shows the knowledge requirements. The third dimension is the object-reference, in the sense of the „people vs. things“ dimension. What a specific task means (for a single worker or within an occupation) is reflected by its position in this three-dimensional space. Differences of these meanings between occupations or branches are also reflected in different positions. This visualizes how employees see their occupations and how occupations differ – even on the individual level. If we now also take the temporal perspective into account (as in changes in positions over time) we can show how occupations and their tasks have changed within one context (e.g. economic branch) over time and, for example, how technological innovations are mirrored in these changes.

There are more possibilities for comparisons. In the following, we are going to analyze differences in occupations between the segment of renewable energies and other branches in Germany. With the energy transition different and new products have come to the market and firms and workers had to adapt to this. This could mean for specific tasks to change within the context of renewable energies, but also for occupations. Exercised occupations (with corresponding vocational training occupations) are being set in a specific and different context within renewable energies. Trained industrial mechanics („Industriemechaniker") perform their tasks differently within the context of machine building, where they might produce and build production streets used by other firms. But within renewable energies they might be building up wind power stations. Roofers can be working in traditional roofing firms but also in firms where they are specialized on installing solar collectors or solar panels. For both occupations the different contexts will lead to different positions in the three-dimensional space.[2]

[2] With this we are also able to detect differences in skill and qualificational requirements inside occupations which can then be used to determine whether new skills or qualificational profiles might have to be included into vocational training regulations.

3. The effects of a changed production structure on tasks in the example of Germany's energy transition

So far, there is no empirical evidence for the effects of Smart Industry. However, for the example of a rather sudden change in production our model may reveal valuable insights.

The Fokushima reactor accident accelerated the German energy transition. There is a national initiative aiming for about 20% of Germany's gross energy consumption in 2020 to be produced by renewable energies which should increase to around 30%in 2030. Another goal of our government for 2020 is for this share to even have reached 35%. This can only be achieved by utilizing a broad mix of renewable energy sources. These encompass all fields using regenerative sources for the production of energy, among which are technologies like solar energy, biomass, hydropower, tidal power, wind energy, geothermal energy, osmosis and others.

3.1 Data

In order to assess changes in the international division of labor on regional workforces we need to analyze the division of labor from different perspectives. It is necessary to look at the development of occupational contents from both, the employers' and the employees' perspective. Firms have to amend to new trends and are innovative in developing new products and services; and these innovations put changing requirements on the employees. We link both perspectives on the level of branches, occupations, tasks and requirements.

As an example, we here present the development from the employees' point of view. The perspective of employers[3] is currently being evaluated. The results are expected in September 2015.

For the employees' perspective we use data from the BIBB-BAuA Employment Survey 2012 (HALL et al. 2014). This is a representative computer assisted telephone interview (CATI) survey of 20,036 persons in core-employment (ILO-definition: minimum of 10 hours paid work a week) in Germany. Respondents were asked about a number of characteristics of their workplace, their work-tasks and the requirements they need to fulfill as well as the competences they bring into their work. The survey with an average duration of 40 minutes also asked about work-related health issues, the qualification processes of the individuals (in retrospective) and their social status. Of all respondents approximately 2,200 employees are in some way related to renewable energies, either direct (i.e. their tasks have something to do with it) or via their firms. With these 2,200 respondents we were able to do a follow-up survey on employees in the renewable energies sector.

3.2 Operationalization and first results

We focused on five of the aforementioned segments of renewable energies and thus came to a pretty narrow definition and operationalization of renewable energies. In our follow-up survey we asked about the economic sector of the firms that had to do with renewable energies. Since a firm can work in more than one business segment

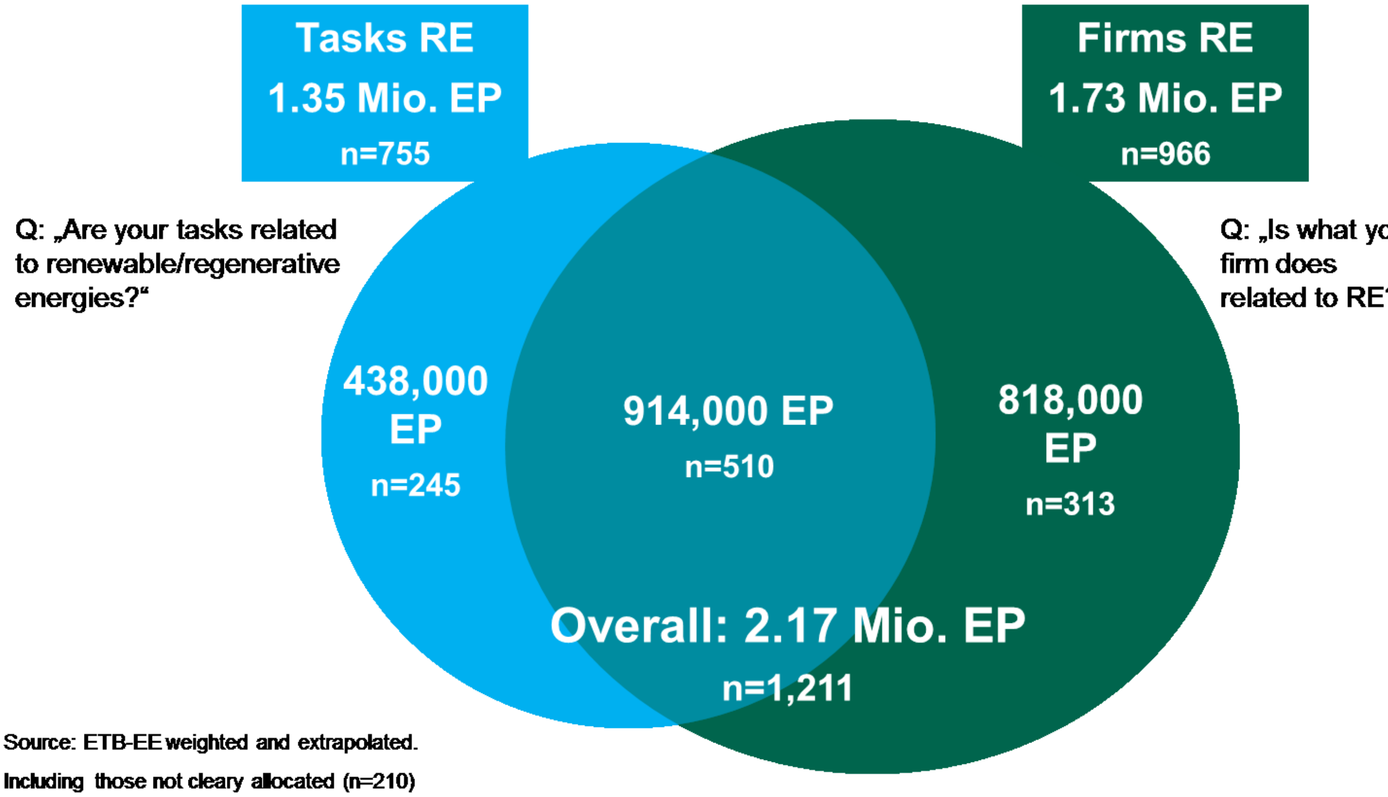
[3] For the employers' perspective we were able to use data from a BIBB-extract of job-openings registered with the Employment Agency of the years 2011, 2012 and 2013. For every year the Federal Institute for Vocational Education and Training receives a copy of the registered openings at a target date. These data include almost all the usual job advertisement information, albeit they are anonymised. The data-base now entails approximately 1.5 million job-ads with information on requirements (full text), sought qualifications (as open text), as well as branches and occupations (both classified). With text retrieval we could establish that there are about 8,000 openings related to renewable energies which we also analyzed.
In a further step, we did qualitative analyses based on guided interviews with HR management personnel of firms who had job openings related to renewable energies (due to actuality from online job exchanges).

we allowed for multiple answers and found that the shares within firms of the five segments are represented as follows: The highest share has solar energy with 59.7%, while wind-energy (39.3%) and biomass (37.7%) are almost equally popular among firms. Next are geothermal energy (29.4%) and hydropower (22.0%). It follows that within the German energy transition the expansion focuses on solar energy, wind energy and biomass, with geothermal energy and hydropower being less prominent.

Being a cross-sectional area, the main segment of renewable energies is interlaced with different branches, namely development, production, logistics and assembling of products, but also distribution, marketing and use of energy. It is a broad area of industrial, technical and commercial tasks, jobs and occupations. So our main questions were: “Who works in renewable energies?” And “Can we detect specific requirements and tasks within renewable energies? Does working in renewable energies differ from working on the same task but in other branches or occupations regarding shares of routine and cognitive requirements?”

To answer these questions we utilized two methodological approaches. On the one hand, we conducted a follow-up survey on around 1,700 (final sample size) employed persons via CATI of the BIBB/BAuA Employment Survey 2012, who stated that either their jobs or their firms were related to renewable energies.

On the other hand, we conducted another survey of about 8,000 firms in Germany, who had registered job openings with the Employment Agency between 2011 and 2013 with a reference to renewable energies. We can analyze around 1.5 million vacancies registered for that time-span. In the following we will present results of the employee survey only, however, it will be apparent that we are able to take on both perspectives, that of employers as well as employees.



Source: ETB-EE weighted and extrapolated.
Including those not cleary allocated (n=210)

Figure 1

Figure 1 shows the overall employment related to renewable energies. In the Employment Survey we asked two questions to find out whether someone's tasks or work or firm were somehow related to renewable energies. The first question was: „Are your tasks related to renewable or regenerative energies?“ About 1.35 million employed persons in Germany confirmed this. The second question asked if the task was not related to renewable energies: „Is what your firm does related to renewable energies?“ About 1.73 million employed persons confirmed this. Of course, there is an intersection between those whose tasks are related to renewable energies and those whose firms are in this field. About 914 thousand employed persons have a relation, both in their tasks as well as with the firms they work in, to renewable energies. Overall around 2.2 million employed persons work related to renewable energies either through their job-tasks, their firms or both. This is a share of about 5% of all employed persons in Germany.

Looking at the firms focusing on renewable energies we find that they represent 52.7% of all employed persons. This is not to say that more than half of Germany's work-force is actually working in renewable energies, but still they work in firms that have some relation to it. These high shares can partially be explained with the fact that in a firm where one section is related to renewable energies there are other sections (like maybe accounting, kitchen and canteen) that are clearly not.

The firms which are related to renewable energies, predominantly are found in the economic sectors (classified according to WZ 2008) of manufacturing of electrical equipment (10.2%) followed by actual supply of electricity, gas, steam and air conditioning (10.0%) and also specialized construction activities (6.9%). We are also able to distinguish different types of association with renewable energies, for example development, intermediate inputs and assembly versus licensing and financing and the actual running of renewable energy-plants. Less than a third (29.9%) of the employed persons working in firms that are related to renewable energies, work in the branches of actual operators of renewable energy-plants.

We also wanted to find out in which occupations people work if they are in one way or another related to renewable energies. We found that of those whose tasks are related to renewable energies, most employed persons work in the vocational fields of Engineers (13.5%), Electrical Occupations (10.1%), Technicians (10.0%), Metal Construction (7.0%) and Agriculture (5.8%). In the agricultural occupations a lot of persons work with biomass.

Commercial and service occupations, as well as banking and insurance occupations and public sector occupations, are well represented, both for licensing and financing projects and businesses related to renewable energies.

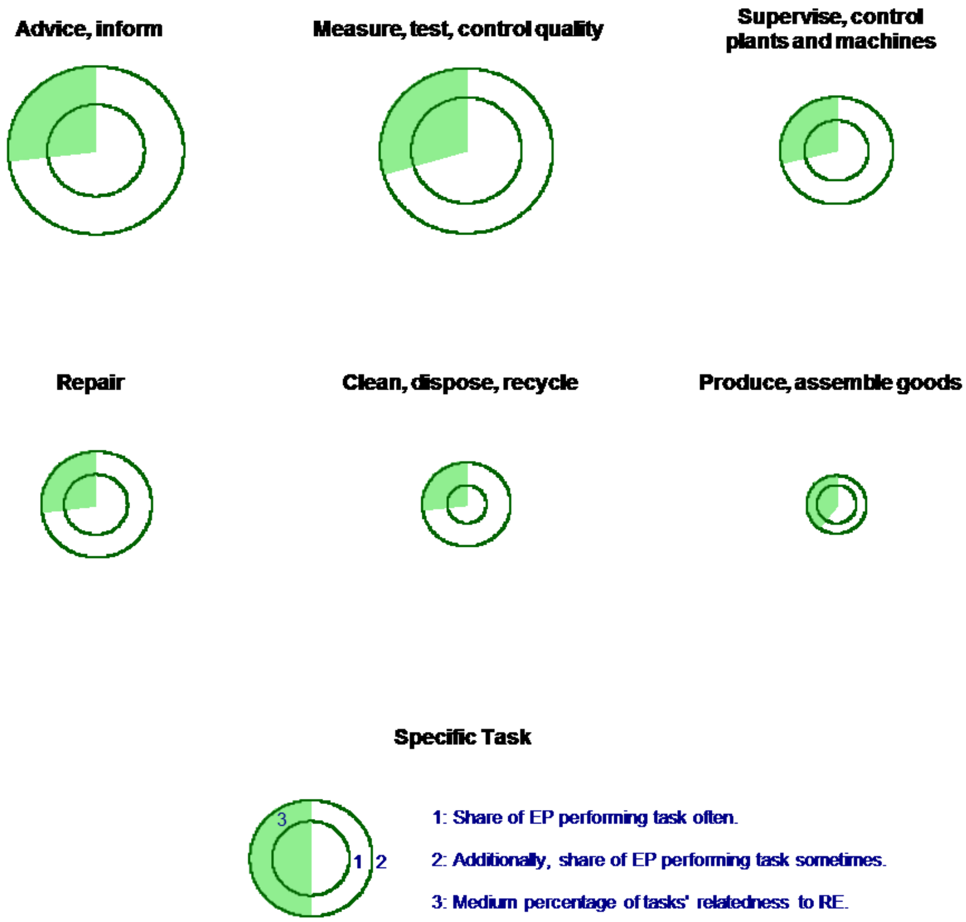


Figure 2

Once we have established who works related to renewable energies and in which branches this happens, we want to take a closer look at the actual work tasks. Since we assume that it is easier for some tasks to be substituted, we closely examined the contents of occupations related to renewable energies. Obviously, if one's tasks are related to renewable energies, not every aspect of these tasks focuses on this field. Figure 2 shows that, on average, about 25% of peoples' tasks related to this field actually focus solely on renewable energies. For example, 79.2% of employed persons perform advising and informing tasks (43.4% often (the inner circle) and another 35.8% sometimes (the outer circle)), however, they devote only 26.7% of their working time on these tasks to activities solely related to renewable energies. On the other hand, only 26.7% perform producing and assembling tasks, of whom 39.2% devote these tasks to purely renewable energies-related activities.

This gives us a weighting with which we can estimate the volume of work for renewable energies-related tasks. About one quarter of the volume of work is directly related to renewable energies. Thus, the full-time equivalent of workers in Germany working in the fields of renewable energies is around 350,000 employed persons (25% of 1.35 million employed persons).

To answer the question as to whether new specific requirements or tasks are detectable and emerging or whether working within renewable energies is different to working in other segments or branches we operationalized the framework, as described above, to map occupational contents and requirements.

Our operationalization builds on tested operationalizations of the three theoretical and conceptual frameworks. The share of routine tasks and requirements, following AUTOR et al.‘s (2003) task-approach on the substitution or supplementation of tasks due to their programmability makes up the routine-dimension and was coded according to whether tasks were often stipulated in minutest detail (ROHRBACH-SCHMIDT/TIEMANN 2013). The “people vs. things”-dimension of the American World-of-Work-Map as in PREDIGER/SWANEY (2004) that is used to build the object-dimension is observed by assessing whether someone has to handle (heavy) objects often or frequently has to work under restrictive conditions (standing, squatting, working over-head). Requirements regarding knowledge-work, where workers are differentiated according to the type of knowledge-worker they are, according to VOLKHOLZ/KÖCHLING (2001), used to build an index based on discriminating the share of those with high knowledge requirements (task-flexible and / or innovative) assessing learning and creativity requirements (TIEMANN 2015).

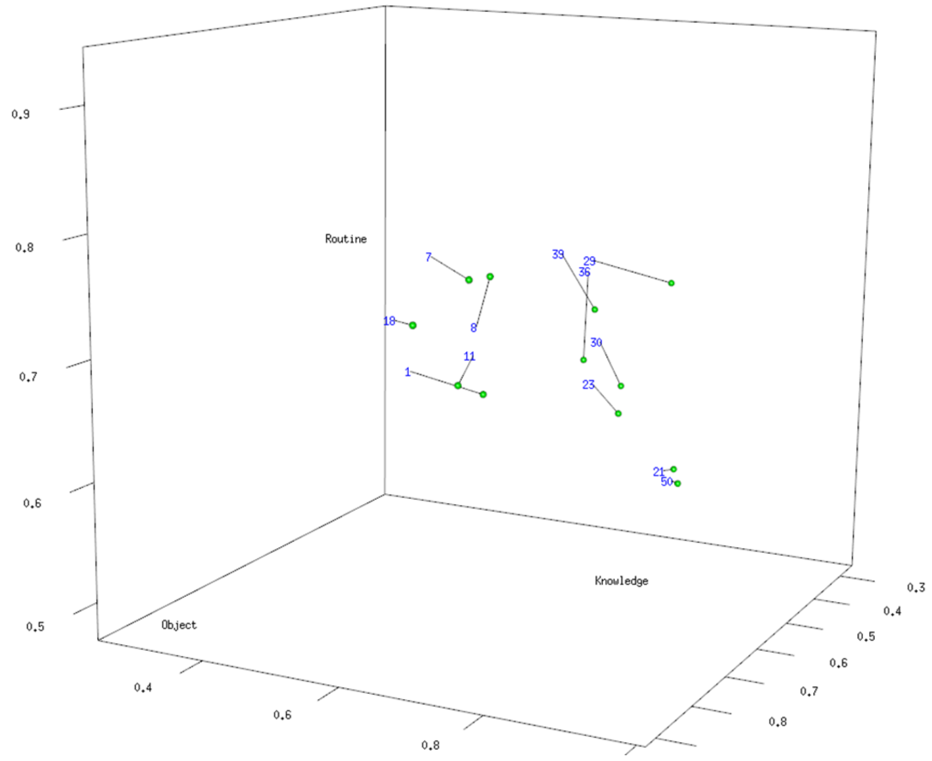


Figure 3

Inside this three-dimensional space, occupations within and outside the renewable energies sector are mapped and compared. Figure 3 gives a visual example on the occupational fields (TIEMANN et al. 2008) level. We see the twelve occupational fields which are most important within renewable energies based on their high shares of workers who stated that their work had something to do with renewable energies. The different positions can be clearly seen; outside renewable energies occupational fields are shown as blue numbers with an arrow leading to the corresponding occupational field within renewable energies. There are three main differences to be observed: 1) For most occupational fields, knowledge requirements are higher within renewable energies and the share of routine tasks is lower. These fields are mostly situated in production, service and trading occupations. 2) For some occupational fields, there are only minor new knowledge requirements (for example Electrical occupations (11) or Administrative occupations in the public sector (36)). New requirements, thus, play a less central role in these occupations. Electricians still mainly have to deal with currents and resistance – no matter if the power was generated in a solar panel or a hydroelectric power plant. 3) There are even some occupations where nothing much changed at all. These are Engineers (21) and Teachers (50). In these occupational fields not even new technologies like those associated with renewable energies pose new learning requirements or make the work tasks less routine – they already have comparatively high knowledge requirements and low routine shares. We find that occupations within renewable energies have a rather low share of routine tasks – or at least below average. For non-technical occupations knowledge requirements are higher in renewable energies-related occupations. On the object-dimension we do not see great differences.

Only the occupational field of Industrial Mechanics, Tool Mechanics (8) shows a higher value on the routine scale for renewable energies-related workers. This field includes workers fitting and setting up machines and plants. Their higher routine-value might be caused by a higher experience with fitting and setting up machines related to renewable energies. Assuming this to be true, we can observe a trend for other occupational fields as well because over time workers will gather experience and their tasks will thus become more routine.

Overall this employees' perspective does not indicate the need for different or new vocational training regulations. Workers can perform the required tasks with their given qualification although within renewable energies their tasks are more varied and less routine as well as more (cognitively) demanding.

In some occupations we could establish different requirements on skills and tasks performed if they were situated in the context of renewable energies. While it is worthwhile knowing these differences as such, there is also the question how workers cope with these different demands. AUTOR/DORN (2009) and AUTOR/HANDEL (2013) propose that workers self-select into occupations and jobs that best fit their individual assets of skills, competences and qualifications. If this holds true also for workplaces within renewable energies we should find good matches for both formal qualifications and competences. However, in some branches and in some occupations dealing with renewable energies is still relatively new. Consequently, self-selection mechanisms cannot work as good as in established areas, because with new and unforeseen challenges information on workplaces and requirements are definitely incomplete. We use a number of indicators to measure the matching of qualifications and requirements in several aspects, as for example an assessment of how well one's training prepared the worker for the current renewable energies-related work, the usually required formal qualification versus the individual formal qualification, whether workers are feeling underchallenged or overchallenged physically, physiologically or if they experience psychological distress, or the satisfaction with one's work and work surroundings.

If you let those employed persons with renewable energies-related tasks assess how well their vocational trainings prepared them for what they do now, about 76.5% indicate that their training did indeed prepare them fairly well. For those with vocational education and training this number is around 72.3% and for those with academic training it is at 78.0%. Overall the preparation through training for their renewable energies-related work seems to be fairly well. Accordingly, especially for those with a vocational education training (77.3%) or academic training (85.3%) formal qualification is indicated to match the required qualification well. However, 63.9% of those without any vocational training work in jobs where a higher formal qualification is usually required. Also, 44.3% of those who graduated in further qualifications (master craftsmen, technicians etc.), work in jobs requiring lower qualifications. This indicates a substantial mismatch, even if we have to express this with caution due to small sample size.

To this point we have presented our findings for the employees' perspective. For a comprehensive analysis the employers' perspective has to be evaluated as well. There may be a tendency for employers seeing their employees as overchallenged. However, as mentioned already results on the employers' perspective can only be delivered in September 2015.

4. On regional adjustments in response to the international division of labor

The expansion of renewable energies has effects beyond the geographic boundaries of Germany. The energy transition in Germany, the different structures in energy generation in Europe, and the specific energy mix and energy market in Europe have increasingly adapted to each other (HELMRICH et al. 2015). Specifically, the exchange of energy across the European countries has increased over time (Figure 4) and, according to plans of the EU commission, will keep being harmonized in the future.

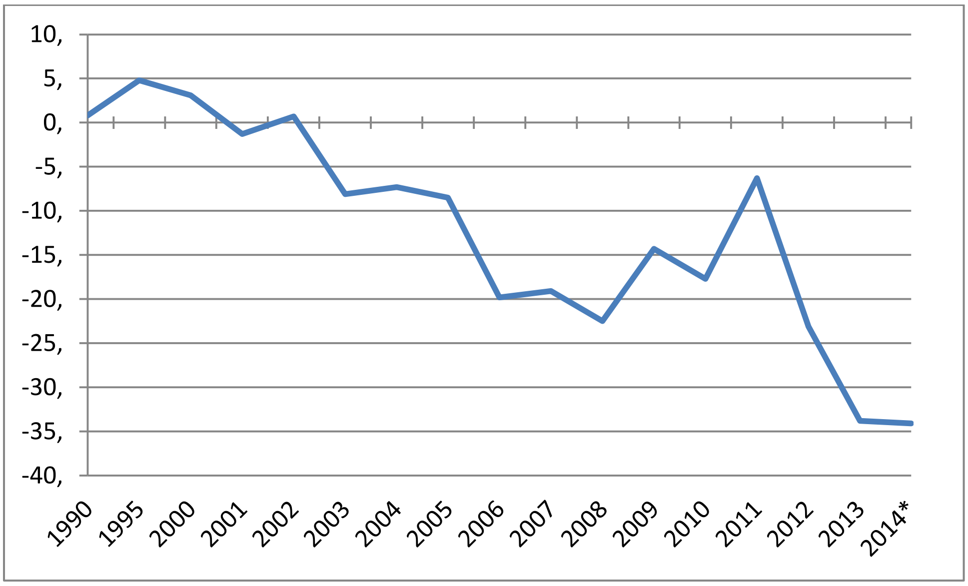


Figure 4 Account balance of the German electricity exchange between 1990 and 2014 (in terrawatt hour), Source: BDEW (2014: estimated)

The energy exchange market is a quite interesting example for labor market implications: Are services from high-skilled workers imported or exported? Are routine production tasks offshored or automated?

As another example, the chemical industry has experienced major changes in recent years regarding their international trade balances. In Germany, the exports as well as the imports have increased in the recent past. Certainly, this cannot be seen yet as consequence of Smart Industry, however, especially in this sector the first implications of IoE are implemented.

Also in the example of the chemical industry in Germany it can be observed that between 2006 and 2012 the share of routine tasks has increased while at the same time the share of cognitive tasks has risen for some groups of workers (Figure 5).

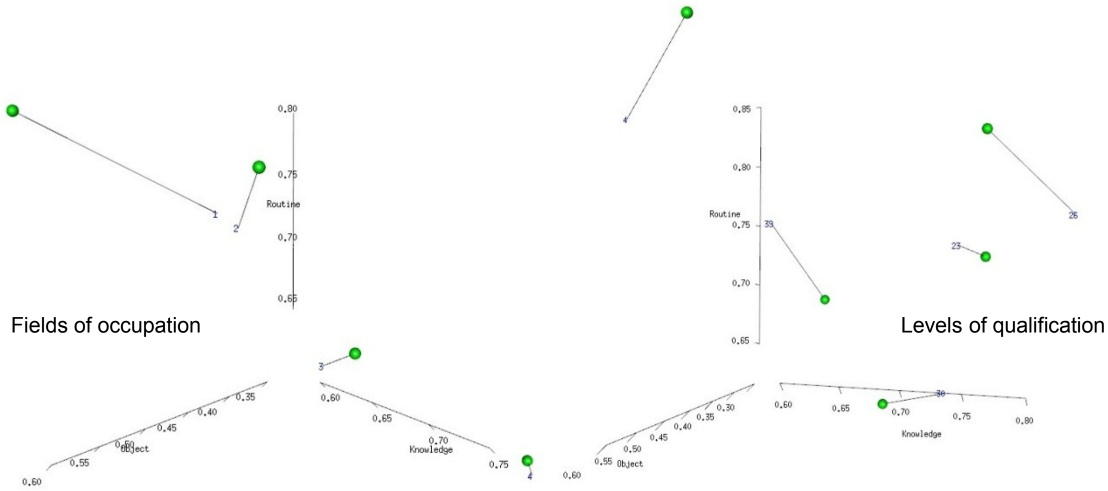


Figure 5

While occupations concerning chemical goods and plastics (4) have experienced an increase of routine, knowledge-work and object-reference components between 2006 and 2012, the extent of object-reference has shrunken for technicians (23) at constant routine and knowledge shares. For specialized technical assistants (26) the share of routine tasks and object-reference have observably increased, while at the same time the knowledge requirements have been reduced. For commercial administrators (39) we detected a reduction of routine tasks, as well as an increase of knowledge requirements and a small increase in the degree of object-reference of the occupation. Similarely, the occupations classified as “miscellaneous commercial occupations” (30) have experienced a small increase in the extent of object-reference of their occupation. However, the knowledge requirements, here, have decreased and the degree of routineness of the occupation has been unchanged.

Overall, production jobs have become more demanding and technical. On the contrary, technicians (holding a position as production plant operators or foremen) have not experienced observable changes in their task mix. Specialized assistants working in production have routinized their jobs. Sales occupations (30) now face reduced knowledge requirements (no new learning requirements) and a higher degree of object-reference (due to the computerization of sales).

The right hand side of figure 5 shows that for the intermediate qualification level (dual vocational education and training and comparable certificates (2)) an increase in all three areas can be observed, while for technicians (3) only the degree of routineness has increased. For workers with an academic education a slight decrease of the knowledge requirements and the degree of object-reference is observable. Furthermore, the share of routine tasks and the knowledge requirements have increased for non-formally qualified workers (1). Consequently, production has been routinized (higher use of technology, higher share of routine tasks, and, thus, an increased “Toyotism”). Note that this process has not only started in 2006, since those who exercise production-control (technicians and specialized technical assistants (3)) experience a rise in routineness, as well. In consequence, computerization has started to quietly penetrate other occupational fields facilitating administration and office work.

Leaving the example of the energy and chemical industry, following the task-approach, some authors (e.g. KEMENY/RIGBY 2012) have investigated which tasks are being traded between economies and are possibly offshored. Contrary to them, following AUTOR/HANDEL 2013, in defining occupational characteristics we explicitly take individual variances in task-composition of occupations and branches into account by analyzing individual-level data. We propose a multidimensional model describing occupational characteristics.

More specific, we propose a concept where our model of analyzing task-content is utilized to describe the effects of globalization and smart production in an international comparison of work tasks within production processes. Work requirements (evaluated based on branches and subsequently deduced for occupations, jobs and tasks) will differ in scope between economies and thus have different effects on national labor forces. Assuming the production of a certain good is comparable between economies we can also assess the qualification and task requirements of the workforce in the producing countries' branches.

Data needed to capture cognitive task requirements, the extent of object-reference and the share of routine tasks of a job is only available for some countries.[4] Assuming, however, that the requirements and characteristics of tasks in specific economic branches or the production of specific goods are similar across countries, it can be deduced based on the available German, British, and American data which tasks in general are at risk to be substituted in the event of technological change. Notwithstanding, it cannot be ascertained yet a) whether these tasks are actually substituted (because this concerns a future event) and b) how they will be substituted (new computers/computerized machines or outsourcing perhaps even from another country).

Economic sectors have a relatively rigid structure of task characteristics. From existing, aforementioned studies we know which branches have particularly high shares of routine tasks. International trade statistics reveal information on combined production inputs and the flow of goods for the commodity group and for the branches, respectively. A change in these parameters can indicate a structural change.

Based on the share of routine tasks of a branch X in year t_0 producing good Y, we can establish:

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[4] There are the British Skills and Employment Surveys (http://www.cardiff.ac.uk/socsi/ses2012/index.html (02.03.2015)) and for the US PDII data used by AUTOR/HANDEL (2013) as well as the STAMP data on skills, technologies and management practices (HANDEL 2007).

If branch X was characterized by a high share of routine tasks in year t_0, it will a) not be characterized by a high share in year t_1 (other tasks) and b) good Y will either be still produced in X (indicating a substitution of tasks by digitalization within the country itself) or will not be produced in X anymore (indicating offshoring of the tasks abroad). Furthermore, if the latter holds it should be retraceable in the international trade statistics to which country and branch the production of Y has been offshored.

Based on this consideration the change in combined production inputs of the branches within their national economies can be used to evaluate the extent of globalization and digitalization of these branches. A higher degree of globalization and digitalization should result, according to the presented theories, in a change of structure of national labor markets in favor of higher cognitive task requirements and diversified tasks or in favor of higher shares of routine tasks.

5. Conclusion

There are a number of general mechanisms we see as driving forces for recent and ongoing economic change. They lead to continually increasing innovation pressure, increasing complexity and dynamics in value-added chains and a rethinking of process-control. This can be summed as the digitalization of the economy.

Our concern is with how and which jobs will change due to these processes. For this purpose we developed a theoretically grounded model for describing occupational content, enabling us to perform comparative analysis of various kinds. Looking at the segment of renewable energies, we found that changes (decentralization of production, new technologies, policies) lead to rising knowledge requirements and decreasing routine contents. Both should only prevail for some time, as with time knowledge becomes incorporated and widespread and routine contents will increase again. For the sector of chemistry we found that production has been routinized, while technological processes pose continually rising knowledge requirements.

Since our model enables us to define the structure of occupational contents and qualifications within a given branch for the production of a given good, we can then deduce how, due to international trade, if tasks are offshored, regional workforces (in the selling and the buying country) will be affected.

As future developments of smart industry, big data and globalization - especially the international distribution of work and activities – are still to be assessed, they are currently neither qualitatively nor quantitatively predictable. This paper outlines an instrument for observing, describing and quantifying developments on the labor market initiated by new structures. The instrument is based on a national model for the analysis of changes in activities and training requirements in the context of changing economic conditions and production structures.

It provides sufficient starting points for building, surveying and analyzing international processes and changes with little additional data requirements.

This project is not yet completed. First internationally comparative empirical analysis can be presented in September.

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