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ARTICLE

Modelling reallocation processes in long-term labour market projections

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Abstract Long-term labour market projections are a popular tool for assessing future skill needs and the possibility of skill shortages. It is often noted that reallocation processes in the German labour market are hindered due to its strong standardization and occupational segmentation. However, it is possible that persons leave the occupation for which they have been trained for. Disregarding such reallocations and their dynamics in the projection model is likely to distort the results and lead to inaccurate practical advice.

In this article, we describe for the first time, how reallocations in the labour market can be modelled using occupational flexibility matrices and wage dynamics. Here, it is shown that employers react to labour scarcity by increasing wages to attract workers who to some extent can adjust their mobility behaviour accordingly. We analyse the aggregate impact of this implementation of a reallocation process of labour supply on the projection results by the means of scenario comparisons. Our results suggest that considering reallocations but also additionally their dynamics has substantial effects on the projection outcomes. They help draw an insightful picture of the future labour market and prevent over- or understating the potential for labour shortages in several occupations.

We conclude that the assumptions about how reallocations differ by occupation and to what extent they can be realized by wage impulses is essential for projection results and their interpretation. Furthermore, we find that in the German labour market, wage adjustments cannot balance the labour demand and supply for occupations completely.

Keywords Labour market · Projections · Germany · Occupational mobility · Education · Wage development

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Modellierung von Anpassungsprozessen in langfristigen Arbeitsmarktprojektionen

Zusammenfassung Langfristige Arbeitsmarktprojektionen stellen ein beliebtes Analyseinstrument dar, um zukünftige Fachkräftebedarfe und -engpässe aufzuzeigen. Es wird oft angemerkt, dass gerade der stark standardisierte und beruflich segmentierte deutsche Arbeitsmarkt Reallokationsprozesse von Arbeitsangebot und -bedarf nach Berufen erschwert. Nichtsdestotrotz sind Wechsel aus dem erlernten Beruf keine Seltenheit und müssen bei einer langfristigen Projektion nach Berufen berücksichtigt werden, sofern keine inadäquaten Handlungsempfehlungen aus vermeintlichen Fachkräfteengpässen und -überschüssen abgeleitet werden sollen.

In diesem Artikel beschreiben wir erstmals, wie die Implementierung eines Reallokationsprozesses durch berufliche Flexibilitätsmatrizen und berufsfeldspezifischer Löhne stattfinden kann. So zeigen wir, dass Arbeitgeber auf Engpässe durch Lohnerhöhungen reagieren, woraufhin Arbeitnehmer ihr Mobilitätsverhalten anpassen. Anhand von Szenarien analysieren wir die Auswirkungen unterschiedlicher Annahmen zur Lohnentwicklung in den Berufen und deren Effekte auf das Anpassungsverhalten des Arbeitsangebots. Unsere Ergebnisse zeigen, dass sich die Berücksichtigung beruflichen Mobilitätsverhaltens sowie eine dynamische Entwicklung desselben substanziell in den langfristigen Projektionsergebnissen niederschlagen. Hierdurch ergibt sich ein differenzierteres Bild über mögliche Fachkräfteengpässe und -überhänge sowie mögliche Handlungsempfehlungen.

Als Fazit lässt sich festhalten, dass mögliche Lohnanpassungen und damit verbundene Berufswechsel zu einem besseren Ausgleich von Arbeitsangebot und -nachfrage nach Berufen führen können und dass Annahmen über den Ablauf dieser Prozesse das Ergebnis stark beeinflussen. Zudem können wir für den deutschen Arbeitsmarkt konkludieren, dass nicht alle theoretischen Engpässe lediglich über Lohnerhöhungen lösbar sind.

1 Introduction

The German economy and labour market are subject to structural change over time. Demographic change, technological progress, and globalisation will frame the behaviour of market participants. Political planners have a special interest in having some knowledge about the future – be it for budgetary planning or preliminary policy assessments. In addition, regarding future developments of the labour market, a concern is whether the supply of skills will suffice the demand of the economy, such that growth can spur, or whether there is a possibility of labour shortages. Here, long-term labour market projections are a more and more popular tool for policy consulting (Wilson 2001). Today many countries have such projections (cf. for example CEDEFOP 2009 and 2012 for Europe; Dupuy 2012 for the Netherlands; Gajdos and Zmurkow-Poteralska 2014 for Poland; Bonin et al. 2007; Maier et al. 2014; and Vogler-Ludwig and Düll 2013 for Germany; Lapointe et al. 2008 for Canada; Lepic and Koucky 2012 for the Czech Republic; Lockard and Wolf 2012 for the US; Tiainen 2012 for Finland; Papps 2001for New Zealand; UK Commission for Employment and Skills 2011 for the UK).

Especially in Germany, where the labour market is highly segmented into occupation-specific submarkets (cf. Mayer and Carroll 1987; Allmendinger 1989; Shavit and Müller 2000; OECD 2003), the balance of the labour demand and supply hinges on today's education attainment. Here, the occupation represents an institutional link between education and employment (c.f. Weber 1972; Mayer and Carroll 1987; Abraham et al. 2011). In such a market, workers cannot be regarded as homogeneous and perfectly substitutable. The production of different goods or services call for different specialized skills and, therefore, not every employee is suited for every job. This is why, for Germany it is essential to project occupation-specific labour demand and supply in order to yield insightful results (Lapointe et al. 2008; CEDEFOP 2012; Helmrich and Zika 2010).

However, although these submarkets are linked to a specific occupation, they are not totally restrictive. The transferability of task-based human capital enables occupational mobility to related fields (Gathmann and Schönberg 2010). In fact, Nisic and Trübswetter (2012) calculate that every year about 3.4% of Germany's employed population change their occupation. To put this into perspective, Nisic and Trübswetter (2012) calculate a yearly rate of 10.8% in Great Britain. For Denmark, Groes et al. (2015) talk of a yearly occupational mobility rate of 20% and Moscarini and Thomsson (2007) estimate a monthly rate of 3.5% among male workers in the US. Thus, in the international comparison, a yearly rate of 3.4% may actually be a relatively small number. Nevertheless, this level of mobility can to a certain extent be thought to resolve misallocations of the working population. Furthermore, disregarding the opportunities and limitations of occupational flexibility and its dynamics in projection models is likely to distort the results (cf. Brücker et al. 2013; Brunow and Garloff 2011).

Notwithstanding, projection models have to trade-off transparency of results and accuracy to some extent; accurately reflecting all underlying mechanisms may cause separate effects not to be identifiable and results not interpretable (Wilson 2001). Therefore, the decision of whether or not and how to implement reallocation dynamics in a projection model of the German labour market is not trivial.

Helmrich and Zika (2010) for the first time model occupational flexibilities into a long-term projection of the German labour market, the BIBB-IAB qualification and occupational field projections (QuBe, henceforth). Based on this, Maier et al. (2014) propose a dynamic reallocation mechanism for the qube model, which redistributes labour supply to labour demand via occupational mobility given wages. This is a novel approach to model long-term projections and to our knowledge has not been done in any other labour market projection so far. In the model of Maier et al. (2014), employers respond to occupation-specific labour scarcity by raising wages, which in turn causes trained workers and workers from related disciplines to more often offer their work in this occupational submarket. In this paper, we wish to highlight the impact of this modelling approach on the QuBe projection results and the overall importance of considering reallocation mechanism in labour market projections in the context of the evaluation of possible hazards of labour supply shortages in the future. Our analysis will show in which occupations, we can rely on market mechanisms to solve possible labour shortages via wage dynamics and in which occupations, enterprises and policy makers have to intervene by for example improving working conditions in general or providing further educational training.

In the following, we first discuss whether wage-based dynamics of the reallocation process are adequate by reviewing recent literature on this topic (Sect. 2). In the third section, we briefly give an intuitive introduction to the QuBe model and describe its reallocation mechanism in more detail. In the fourth section, we outline the different data sources used for the QuBe model and how the reallocation dynamics where operationalized. Sect. 5 presents results from scenario comparisons, which illustrate the effect of this modelling on the projection results. Here, we first assess the overall impact of implementing the reallocation mechanism in QuBe (Sect. 5.1). Then we show how the dynamic adjustment of employers and workers to each other take a great part in the overall effect (Sect. 5.2). After this, we discuss how the interpretation of the results are strongly influenced also by the implicitly modelled limitations of wage dynamics in balancing the labour market by presenting results from wage policy scenarios (Sect. 5.3) and discussing to what extent the calculated *optimal* flexibility of the workforce is achievable via the wage mechanism (Sect. 5.4). In Sect. 6, we conclude and give an outlook on future research.

2 Theoretical assumptions and related empirical findings

In order to account for reallocation dynamics in their projection model Maier et al. (2014) let employer-set wages partially depend on labour supply scarcity. Labour supply, in turn, responds to differences in relative wages of occupations by changing their occupational mobility behaviour in that the workers propensity to stay in their training occupation correlates positively with a lower outside option. In this model set-up, wage is the only explicit adjustment channel of employers and worker behaviour in response to misallocations of labour. All other factors, which influence mobility decisions of workers, are assumed to follow a constant time trend. Other factors, which drive wage setting of the employer, are assumed to relate to the production process and outside wage pressures.

In the following sections, we will describe this mechanism in more detail and outline its empirical foundation and effect on the projection results. In this section, to start with, we will briefly discuss the choice of a purely wage driven mechanism reflecting on related literature on the topic of turnover, employer recruitment strategy, and the drivers of occupational mobility in general.

2.1 The employer's adjustment mechanism

Projection results are often said to exaggerate the extent of possible labour shortages in the future. This critique often addresses that adjustment mechanisms of employers are neglected in the analysis (cf. for example Brücker et al. 2013). Brunow and Garloff (2011) even reject the idea of future labour market shortages in total. They argue that in the event of a tightening labour market, employers have plenty of ways to adjust adequately and prevent a shortage situation. They suggest that firms will react to the anticipation of a shortage by substituting their labour demands by automating processes or hiring workers from abroad. Also firms could alter their stock of capital and produce less, thereby demanding less labour. Brunow and Garloff (2011) also highlight the importance of wages, which they consider 'upward flexible' enough to attract the necessary labour supply.

Economic theory, likewise, predicts a relationship between wages and relative labour supply. Especially in the search and matching literature labour market tightness explicitly enters the wage equation such that a shortage of applicants always corresponds to higher wages (cf. for example Pissarides 2000). Montgomery (1991), for example, uses a related model set-up to explain wage differences across industries. Here, firms who value filling their vacancy most, pay the highest wage in order to overcome coordination problems and attract the most applicants to their opening.

However, Bechmann et al. (2012) show that wage policy may be less important to German recruiters. They analyse data of the IAB Establishment panel[1], where firms were asked which strategies they used or would use to alleviate labour shortages. The most important strategy, in fact, seems to be further training of the current workforce, which was chosen as very important by 42% of the surveyed firms. Next to other means of recruiting from within the company, as for example later retirements or apprenticeship programs, also the attractiveness of the job offer was stated to be targeted. With 34% of the establishments highlighting its importance making the offer desirable seems to be the second most important strategy of firms. In contrast, wages seem to be less important. Only 11% of the firms consider pay-

[1] The Establishment Panel of the Institute for Employment Research (IAB) representatively surveys about 16,000 German establishments on their employment policies and related topics since 1993.

ing higher wages as an important strategy. It is, however, still a strategy for 47% of the surveyed firms, even though 36% indicate that a main problem concerning recruiting is, in fact, too high wage demands of applicants (Bechmann et al. 2012).

Eventually, Dustman and Glitz (2015) and Dustman et al. (2009) find empirical evidence for the impact of the structure of skill supply on wages. Using IAB Establishment Panel data from 1985 and 1995, Dustman and Glitz (2015) investigate whether employers in West Germany react to a change in the skill mix of the workforce by adjusting wages or the production intensity, where they distinguish between switching to production of goods, which can be produced by the skills available, or producing the same goods but adjusting the skill application. They conclude that firms adjust mainly by the latter. Concerning wage adjustments, they find that wages are only significantly elastic with respect to skill supply in the nontradable and manufacturing sector, where a 1% increase of skill supply corresponds to a 0.4% and 0.1% decrease in wages, respectively. Dustman et al. (2009) come to a similar conclusion. Taking advantage of the change in skill structure of the German labour market induced by the reunification, they show that the relative abundance of lower skilled workers after the integration of the East German Länder increased skill returns.

To sum up, there is evidence of firms reacting to labour market tightness by raising wages in order to attract sufficient applicants to their vacancies. However, the extent of the wage mechanism may be relatively small as firms also use other strategies to overcome recruitment problems. These include training and solutions for better working conditions (cf. Bechmann et al. 2012).

2.2 The worker's adjustment mechanism

In labour economics, there has been a long debate about whether job or occupational mobility is associated with a wage gain or a penalty. The classic island model by Lucas and Prescott (1974) would predict that negative demand shocks motivate workers (low skilled first) to leave their job to seek higher wage opportunities. Likewise the search and matching literature (c.f. Pissarides 2000 for an overview) predicts a positive relationship between job mobility and outside wages, as workers are rational and only move if incentivized. For the German labour market, Fitzenberger and Spitz-Oener (2004) find an overall positive relationship between occupational switches and wages, thereby supporting that occupational mobility mainly serves as a career seeking device.

However, there is also always a non-negligible share of job switchers who have experienced downward mobility (cf. Gibbons and Katz 1991). Whereas voluntary quits are most often associated with separations to higher paying jobs, involuntary lay-offs are associated with a switch to lower wages (McLaughlin 1991), which Gibbons and Katz (1991) explain with the 'lemon effect' causing laid-off workers having troubles with finding a new job. The importance of the nature of the switch is also highlighted by recent results of Fitzenberger et al. (2015). Providing evidence concerning the occupational mobility of recent apprenticeship completers in the German labour market, they find that mere job switches inside the occupation but between firms most often lead to a wage loss, while occupational mobility is associated with a wage gain in most cases. However, they point out that occupation-and-firm switches only result in a gain if this switch reflects an occupational upgrading, while occupation switches within the firm, which reflect a switch to a better fitting position, are usually associated with a wage gain.

Other research points toward the increasing wage inequality. Groes et al. (2015) point out that mainly low and high income earners switch occupations and that downward mobility seems to be a phenomenon of low income earners. An explanation for this, according to Groes et al. (2015), is that occupations with rising productivities layoff their low skilled workers (and typically low wage earners), leaving them to seek work in other occupations, while high skilled workers move out of the declining productivity occupations in order to obtain higher wages. As a result, again only the high skilled workers are hypothesized to experience wage increases when switching their occupation.

The literature on task biased technological change explains the observed trends in wage inequality by job polarization. Emerging new technologies, which automate many routine tasks, and globalisation, which poses new opportunities for offshoring (see also Grossman and Rossi-Hansberg 2008), cause redundancy of domestic labour in some occupations (see for a summary Acemoglu and Autor 2011; Goos et al. 2009). Such a trend can also be found for Germany (cf. Spitz-Oener 2006). Cortes (2016) explains this polarization effect further by the induced sorting on ability among the workforce. According to this, more able workers will sort into occupations with higher non-routine, cognitive task shares, while less able workers switch to high routine, non-cognitive jobs. Therefore, only the more able workers will experience a rise in wages upon a job switch.

Yet another interpretation for the duality of wage outcomes upon occupational changes is presented by Gathmann and Schönberg (2010) and also Geel and Backes-Gellner (2011). They attribute the probability of a wage gain after a switch to the proportion of specificity of the acquired skills in the former occupation. Geel and Backes-Gellner (2011) show that the higher the specificity of skills, the lower occupational mobility. In addition, Gathmann and Schönberg (2010) also show that occupational mobility mostly entails switches to related fields, where skills are best transferable. Apart from the share of specific human capital needed in an occupation, Damelang et al. (2015) indicate that also to the degree of standardisation and occupational closure is important. A higher degree of regulation (meaning the existence of occupation specific VET certificates and study programs) reduces the propensity of leaving the occupation.

Additionally, there are of course also other factors driving job mobility aside from monetary incentives. Cotton and Tuttle (1986), Shaw et al. (1998), Pollmann-Schult (2006), Böckermann and Ilmakunnas (2009), Cottini et al. (2011) all emphasize the importance of physical and psychological hygiene, as well as, a good work life balance for retention of employees. Furthermore, on more regional level, regional mobility within an occupation has to be considered as an alternative to occupational mobility (Reichelt and Abraham 2015).

Furthermore, note that other mechanisms that do not concern occupational mobility may also be used in projection models. Ehing and Moog (2013) point out that the size of the future workforce hinges on assumptions about future labour force participation. Zika et al. (2012) suggest that the amount of hours a person wishes to work significantly impact labour supply, especially in occupations with large shares of part-time workers. This suggests that one could also implement a mechanism, which assumes workers to react to changes in the labour market by altering their participation or their working volume. Also migration flows could dynamically adjust to the labour market situation in a projection model. However, such mechanisms have not been implemented in any projection model so far. In the QuBe model all of these measures are assumed to be stable or to follow a trend in their development.

To sum up, in theory wage impulses should create an incentive to switch occupations. However, not all occupational switches are found to be associated with an increase in wages. Therefore, in the aggregate the effect of wages on occupational mobility may be mediated by downward mobility of a part of the occupation switchers. Indications that the possibility of downward movements is associated with the nature of the task or the prior income level, suggest that wage effects should differ by occupations. In addition, other factors concerning the perceived attractiveness of the occupation seem to have an important impact of occupational mobility.

3 The BIBB-IAB qualification and occupational field projections

In this section, we will describe the underlying model. The QuBe model is a joint project of the Federal Institute for Vocational Education and Training (BIBB) and the Institute for Employment Research (IAB) in collaboration with the Fraunhofer Institute for Applied Information Technology (FIT) and the Institute of Economic Structural Research (GWS). As this paper focuses on possible reallocation mechanisms of labour demand and supply to overcome long-term mismatches at the occupational level, we will only briefly touch on the derivation of labour demand and supply in the QuBe projections and describe the implemented reallocation mechanism more thoroughly. The reader is referred to Maier et al. (2014, 2015) for a detailed description of the model. Note that the working volume is central to the demand side model and results are also available in aggregate hours of work. However, for simplicity in this paper we only focus on results evaluated in the number of persons involved.

The underlying model projects a development path (the baseline scenario) of the German economy into the future given that the currently observable behavioural patterns and trends in the goods, labour and education market will continue on their develop path until 2030. As such, it does not necessarily represent the most likely development, but can be understood as an outlook on the possible structure of the future labour market when every market participant keeps on her current path of motion. Using this approach enables a straight forward interpretation of the results and makes them easily comparable to outcomes of alternative scenarios. In this spirit, modes of behaviour, which cannot be empirically verified, are considered infeasible for the resulting baseline scenario. Thus, for example technological progress is only captured by a constant trend and not assumed to accelerate until 2030. We do, however, implement future changes which have been enacted by legislation and have a relevant effect on the outcome during the projection period. As an example, the baseline scenario takes the new German pension age of 67 into account.

Fig. 1 gives a highly simplified overlook of the QuBe model. Two concurrent processes essentially determine labour market outcomes: The evolution of labour supply driven by demographic change (left box) and the evolution of labour demand, which is driven by economic structural change (right box). Both labour supply and demand developments are projected until 2030. Essential to the model is the distinction between the training occupation, which workers are associated with on the supply side, and exercised occupation, which workers relate to on the demand side of the labour market.

On the supply side, we project the numbers of new labour supply, those leaving the labour market, and ultimately the total supply given their sex, age, qualification level, and training occupation. For this purpose, the Fraunhofer FIT developed a cohort component model (c.f. Whelpton 1936; Blien et al. 1990; more specifically for QuBe see also Kalinowski and Quinke 2010), which subdivides the popula-

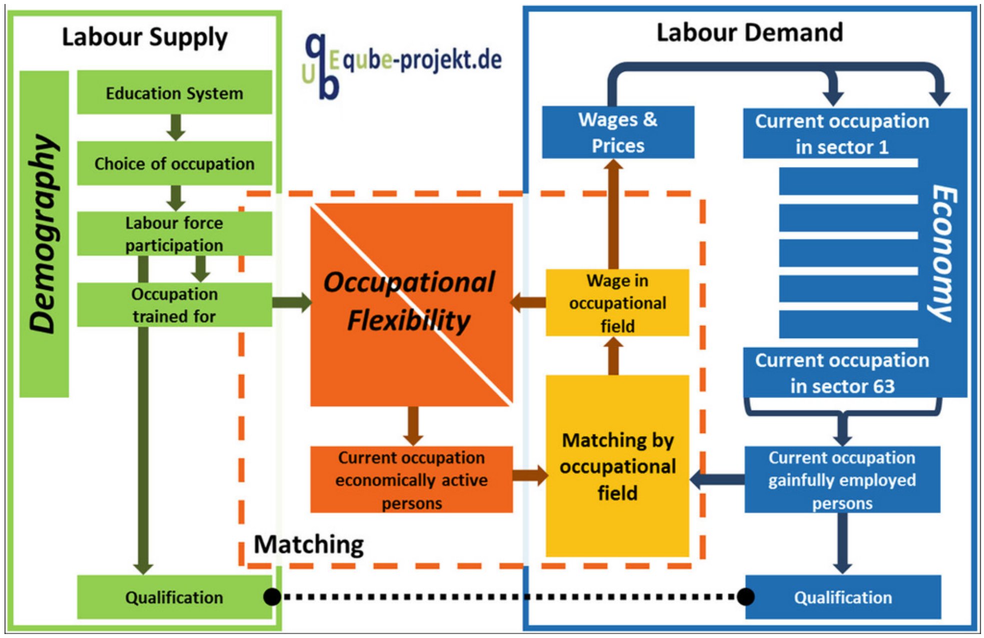

Fig. 1 The QuBe model (Source: QuBe projections; 3rd wave)

tion according to sex, age, and qualification characteristics and extrapolates the in- and outflows of these subgroups into the future (BIBB-FIT model). The movements between groups summarize ageing given births and deaths, migration, and qualification attainment behaviour. The latter is simulated with a nested transition model of the German education system. Here, pupils are allocated and transitioning between high school tracks, entering the vocational education system, switching between higher education and vocational training programs and, finally, according to the overall completion rates of the different programs finishing by obtaining a credential assigning them to a qualification level and according to the prevailing empiric rates of occupation attainment a training occupation, which they can use in the labour market to earn wage profits. Of course, infeasible transitions which cannot be identified in the data are not considered. Note further that people in or without any vocational education do not have a training occupation by definition and can, therefore, only be associated with an exercised occupation if they are economically active. The number of economically active persons for each subgroup is calculated using group specific participation rates, which are forecasted with a logistic trend model.

On the demand side, we calculate the total number of persons needed to manufacture and provide the total number of goods and services produced in Germany given their qualification and exercised occupation for each economic sector. We refer to this as realised demand; vacancies are not taken into account.[2] While the short-term may be concerned with, for example, dealing with the consequences of the euro crisis, structural change is the essential determinant of labour demand in the long-term. In pursuance of accurately reflecting structural change, QuBe relies on the QINFORGE model developed by the GWS – a further development of the IAB-INFORGE model (Meyer et al. 2007; Schnur and Zika 2009; Maier et al. 2015). QINFORGE is an econometric input-output model for Germany, which is

[2] Vacancies are not taken into consideration in the QuBe long-term projections for four reasons:.

Micro-macro problem: At the micro-economic level, the non-filling of a vacancy leads to a loss if it causes the company concerned to refuse orders and, thus, to restrict or not to expand production capacity. This does not, however, necessarily mean that there is a corresponding loss in production for the economy as a whole, i. e. at the macro-economic level. Indeed, it may instead lead to the acceptance of the order by another domestic company, which instead expands its production capacity, offsetting the potential loss in demand.

Methodology: Without further background knowledge, no expansion demand can be deduced solely from an increase in vacancies, since the number of vacancies cannot be differentiated according to replacement and expansion demand.

Long-term observation: From an economic point of view, vacancies only become a problem – if at all – if they cannot be filled. Even if we do not impute complete information or rational agents, problems with an unfilled vacancy should vanish with time as a result of the reallocation process. Therefore, we safely that the number of vacancies always returns to its frictional level in the long term.

Data quality: Reported vacancies statistics by the Federal Employment Agency (BA) also contain vacancies that do not have to be filled necessarily. The reasons for this may be multifarious: neglect of reporting a successful filling by the company or duplicate reports. Although this problem does not arise with data of the Job Vacancy Survey conducted by the IAB, the data here is not available to a sufficient depth of occupational disaggregation.

deeply disaggregated by economic sectors and commodity groups. To describe this model in a very simplified way, let state, employers, and private households invest and consume, thereby generating demand. On top, there is a demand for German products from abroad. Also, international trade poses price pressures on exports and imports, which affect price levels for consumption but also production goods in Germany. This affects the demand for imported goods and also raises unit costs for German products. Given the individual input-output interdependencies of the economic sectors, the production level is raised or lowered accordingly. Production results in value creation and employment, leading again to a reaction of consumption and investments. In an iterative process these described interdependencies between the different economic actors determine the final growth path of Germany and the level of employment per economic sector, which, according to the structure of each sector, translates to a demand of labour for each exercised occupation.

Having derived both labour demand and supply, we continue now with a more detailed description of the reallocation mechanism, which connects both sides (see Fig. 1). Sect. 3.1 will be concerned with the wage adjustment mechanism of employers, while Sect. 3.2 will outline the occupational flexibility adjustment mechanism of workers. Together both mechanisms form the reallocation process imbedded in the QuBe model. However, we wish to point out that such a reallocation mechanism could easily be transferred to other projection models.

3.1 Modelling wage adjustment due to skill shortages

This section describes the labour demand adjustment mechanism through the wage channel with respect to labour market tightness. Note that the occupation dimension to a very high extent already captures the informational input of qualification.

The starting point is the occupation specific wage, which is a function of the total average wage in the economy (W), and a scarcity term. The latter is given by the ratio of labour demand (ld_o) and supply (ls_o) in the occupation and operationalizes the overall tightness within the occupational submarket. W itself is a function of aggregate per capita labour productivity, overall fluctuation in prices and an aggregate term of the labour market tightness for the entire economy. Additionally, a constant is included, which captures all occupation-specific time invariant factors, which also determine occupation wages. This captures, for example, the extent to which employers could overcome labour shortages by raising employee productivity by innovative technologies or further training within a certain occupation (cf. Sect. 2.1).

$$w_o = \alpha_1 + \alpha_2 W + \alpha_3 \frac{ld_o}{ls_o} \tag{1}$$

In a further step, the industry- and occupation-specific wage ($w_{o,i}$) is modelled. Here, note that the QuBe model assumes an underlying productivity-based wage policy. Thus, industry level wage differences within occupations are explained by differences in labour productivity. Thus,

$$w_{o,i} = \beta_1 + \beta_2 w_o + \beta_3 lpp_i, \tag{2}$$

where lpp_i denotes the industry specific productivity of labour. Again, a constant is included to account for any time invariant determinants of the level of industry- and occupation-specific wages.

After modelling the wage dependency on labour scarcity, the industry and occupation specific wage is integrated into the projection of labour demand. Demand for labour by occupation and industry is explained by the relative application of the occupation in the economic sector as given by its contribution to total industry volume of work, i. e. occupation- and industry-specific volume of work relative to total industry volume of work. The industry-specific volume of work is driven by the output level and constraint by industry-specific wage costs. Also, due to technological progress it is explained by a decreasing time trend indicating the growing efficiency of labour inputs. The connection between volume of work and labour scarcity is modelled by Eq. 3.

$$\frac{vow_{o,i}}{vow_i} = \gamma_1 + \gamma_2 \frac{w_{o,i}}{w_i} + \gamma_3 t \tag{3}$$

The equation states that the relative differences in work inputs between occupations in the same industry is explained by a time trend (t) and the relative wage difference ($\frac{w_{o,i}}{w_i}$). The latter depends on the occupation specific labour scarcity (cf. Eq. 1). Thus, relatively scarce labour will be relatively pricy such that its application in the production process measured by its volume of work is lowered. Given that the amount of annual hours worked by one labourer in this industry and occupation does not change, there will be a decrease in labour demand in this occupation in this industry. Note that an adverse shock to scarcity causes a perturbation, since the resulting change in labour demand will in turn alter the scarcity measure again, which moderates wages and labour demand. Such a perturbation also affects other industry wages through a change in aggregate income. This modifies consumer demand, which is the main driver for production in a lot of industries. An increased production level induces a raise in labour demand, which again starts off the process of wage adjustments in the affected industries.

3.2 Modelling occupational flexibility due to wage adjustments

This section outlines the reallocation process of labour supply on the occupational level through the wage channel. The basic idea is that within the model occupational switches are accounted for, i. e. it is not assumed that a person who has been trained in a certain occupation automatically is part of this occupation-specific labour supply. Therefore, the starting point of modelling this mechanism is the distribution of the skilled labour force by training occupation over all exercised occupations. Persons, for which the training and the exercised occupation are identical, are called stayers, henceforth. The share of stayers in the training occupation, to, is denoted by $stayer_{to}$.

This stayer share is assumed to be time variant and reacts to impulses of the economic environment. In the model, these impulses are captured by outside wage opportunities given by a training occupation specific reference wage (w_{to}^{ref}), which is the weighted average of the wages of all (inside and outside) work opportunities, which are feasible (considering the distribution over exercised occupations) for a certain training occupation. The share of stayers is determined by equation

$$stayer_{to} = \delta_1 + \delta_2 \frac{w_{to}}{w_{to}^{ref}} \tag{4}$$

where w_{to} denotes the wage in the training occupation, to. The equation states that whenever a certain training occupation experiences an increase in wages while the wage level remains constant in all other reference occupations, it will become relatively more profitable to stay in the training occupation, thus, causing a rise in the share of stayers. The extent to which the intent to stay in the training occupation reacts to outside wage pressures is determined by δ_2, which is the training occupation-specific wage elasticity of the propensity to stay. Again, a wage rise triggers a perturbation, where the aggregate effects on labour supply cause a re-evaluation of wages and labour demand, which, in turn, causes preceding adjustments of the supply side and so on.

4 Operationalization and estimation of the QuBe model

In the following section, we briefly present the data used to estimate the QuBe model and point out some indication of the explanatory power of scarcity for labour demand and wages for labour supply, respectively, before we further highlight the magnitude of their impact by sensitivity analyses in the subsequent section.

4.1 Data and classifications

For the QuBe model, data from a number of sources was merged to generate a unique data set, which outlines a deeply disaggregated picture of the German economy and the labour market. For structural information, we rely on data of the years 1996 to 2011 retrieved from the German Microcensus (Labour Force Survey), which is a yearly sample survey of roughly 1% of the German households. It is the main source of information for the population structure with regard to age, sex, qualification level, employment status and training occupation (Maier and Helmrich 2012). It also provides data on the distribution of gainfully employed persons over industries and exercised occupations for the years 2005 to 2011 and can, therefore, also be used to analyse occupational switches. Furthermore, it contains data on self-employed and civil servants. No other survey delivers a more complete picture for all these characteristics.

On the demand side, information on consumption, prices, and production for the years 1991 to 2011 is retrieved from the National Accounts of the Federal Statistical Office (FSO, henceforth). Especially, the input-output-tables enable a modelling of the interindustry dependencies within the production process.

For the wage development, we retrieve daily wages for full-time employees of the years 1993 to 2011 from the IAB Employment History Data (EHD), which records all employment relationships subject to social security contributions in Germany and captures information about working days per person and wage totals by economic industry, occupation exercised and qualification level. By relying on this data set, note that we misrepresent wages of civil servants, self-employed and helping family members. Also, wages of top income earners are underestimated due to legal censorship in the upper income range. However, employees subject to social insurance contributions represent the majority of the work force (about 89% in 2015) and there is no larger and more detailed dataset on gross wages available in Germany. We, therefore, use the wage development of the EHD as indicator for the general occupation and industry specific wage development. Note also, that with the underlying data the new legislation on minimum wages is not yet accounted for.[3]

Furthermore, we use the 12th Coordinated Population Forecast of the Federal Statistical Office 'Version 1–W2: Upper limit of the "medium" population' until 2060 to quantify the population by age and sex in the future. To

[3] A preliminary assessment of the minimum wage policy based on the QuBe model was presented on the 11th International Conference Challenges of Europe in 2015. The results suggest a negative overall impact on the economy. Service-oriented industries and professions with low to medium-skilled qualifications are likely to be exposed the most. See also URL: https://www.efst.hr/eitconf/index.php?p=proceedings.

be able to account for the current developments in the population in both absolute terms and in terms of their changed age structure, Version 1-W2 was adapted to the new results of the Census 2011. Note that Version 1-W2 is meant to reflect an upper limit of the population, however, understates the current net migration inflows of, in particular, political and religious refugees. Accounting for this is likely to impact the projection outcomes. As an example, the demand for teachers may be increased considering the high share of young migrants. Therefore, the QuBe projection results, as well, are outdated in this sense. This illustrates how the plausibility of long-term projections strongly hinges on current beliefs of future developments. However, to show the effects of different modelling assumptions concerning the adjustment process on the projection results it can also be helpful to isolate effects from such factors. We, therefore, think that our results can be used to visualize the impact of the modelling of the reallocation process, even though the recent migration behaviour is not taken into account.

For the calculation of new labour supply by qualification level and formal vocational qualification, the forecasts of the Conference of Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany of pupils and graduates from German high schools and university entrants until 2025 are used as a benchmark for the future development in schools and higher education. The retrieved entry, graduation and transition rates for 2025 are held constant thereafter until 2030.

For both the supply and the demand side the date is aggregated using the same classification schemes. The International Standard Classification of Education 1997 is used to differentiate between qualification or skill levels. For the occupation dimension, the 369 occupational categories (3-digit code) of the 1992 Classification of Occupations (KldB92) are aggregated according to the 54 occupational fields (OF, henceforth) of Tiemann et al. (2008). Using the OF to distinguish between occupations prevents artefacts in the modelling of occupation switches, which particularly occur in the manufacturing sectors because the KldB92 is very detailed here. For an easier visualisation, we report our results for 20 main occupational fields (MOF, henceforth) – an aggregated version of the OF (see Table 5 in the appendix). Economic sectors are classified using the aggregation to 63 industries of the National Classification of Economic Activities of 2008 (Table 6 in the appendix).

To harmonise the supply and demand side data, the number of persons in active employment as retrieved from the Microcensus is re-extrapolated to match the total number as recorded in the National Accounts, while retaining the structure of the population by age, sex, educational level and formal vocational qualification from the Microcensus. Throughout, 2011 is the base year of the QuBe projection. The reason is that firstly, the Microcensus 2011 was the latest available Microcensus when the 3rd wave of the QuBe project was computed. Secondly, it was also the last Microcensus, which used the KldB92 to classify occupations. Thereafter a harmonization of past data to the 2010 Classification of Occupations is needed.

4.2 Estimation of the QuBe model

In this section, we briefly outline how the before mentioned equations of the reallocation mechanisms were estimated.

Using data from 1993 to 2011 on daily wages of full-time employees, working volume and labour productivity, Eqs. 1 to 3 were estimated adding an error term to the right hand side, where the subscripts o and i are captured by the 54 OF and the 63 aggregated economic sectors, respectively. The t-test for the parameters of Eq. 1 indicate (at a significance level of 5%) that the measure of labor scarcity is a good, necessary and observable predictor for wage level differences between occupations. Especially for ‘occupations concerning the production of chemicals and plastics wages’ largely, significantly depend on labour market tightness. However, in 8 of the 54 OF, the effect of scarcity is found to be insignificant. An example is the ‘public administration occupations’. An explanation could be the lack of variation in the scarcity variable in these OF.

Eq. 2 uses the results of Eq. 1 for estimating occupation-specific wages in each of 63 industrial sectors. A potential of 3402 wages are estimated accordingly. However, not all occupation and industry combinations exist: taking 2010 as base year, only 75% of all possible combinations report employment. The corresponding regressions are estimated using ordinary least squares. The estimated parameters are evaluated against the R^2 (greater than 0.90), Durbin-Watson test statistic (between –1 and 1), and the p-value (below or at 0.05). In total, it was possible to identify wage responsiveness in 1.513 occupation-specific industry wages which means that roughly 30 thousand employees are wage-sensitive in an econometric sense. Nonetheless, there exist some cases for which no conclusions about the existence of an industry-specific penalty or mark-up can be made, because either the coefficient of the industry-specific labour productivity is insignificant or the regression is subject to autocorrelation. In these 28% of the cases a default option is used, using the OF wage to update the industry specific OF wages. A similar approach is used for the estimation of Eq. 3, where in cases of autocorrelation or insignificance of the wage relation by default the relative inputs of occupations is kept constant. Therefore, not in all cases changes in the labour supply transmit a change in wages and likewise not all wage changes induce a change in the occupational structure of the industry. For the estimation of Eq. 4, firstly, the distribution of formally trained workers by 54 training OF over the exercised OF is calculated for each age, sex

Table 1 Occupational flexibility matrix from formal vocational qualification to occupation exercised in 2011 for 20 MOF

	MOF formal vocational qualification	Switches to MOF exercised (in %)																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1	Raw material processing occupation	51.1	3.1	1.6	3.5	0.6	2.9	3.2	2.5	10.9	1.2	2.1	4.2	4.9	0.9	1.2	2.6	0.9	1.2	0.8	0.6	100
2	Auxiliary workers, janitors	0.0	66.3	6.6	6.9	0.0	0.0	0.0	1.4	2.6	1.7	0.0	1.7	2.6	0.0	2.9	4.6	1.3	0.0	0.0	1.5	100
3	Metal production and processing, installation, electrical occupations	1.4	5.8	36.6	3.6	1.3	9.8	1.3	2.6	10.2	2.2	1.1	2.0	3.8	3.4	8.5	3.5	1.4	0.7	0.4	0.5	100
4	Construction, woodworking, plastic manuf. occupations	2.1	5.8	3.2	46.9	1.9	5.5	1.7	2.0	14.0	2.3	1.1	2.8	2.7	1.0	2.1	2.3	0.9	0.8	0.5	0.5	100
5	Other processing, producing and maintaining occupations	1.8	4.1	4.3	3.4	25.3	7.6	5.4	3.7	16.6	2.1	3.3	7.2	4.6	0.9	2.9	2.6	1.2	1.6	0.7	0.6	100
6	Machinery and equipment steering/ maintenance occup	1.2	3.5	7.4	2.7	3.1	41.3	2.0	2.5	10.8	2.1	1.6	3.5	3.9	1.8	5.2	2.7	2.8	0.9	0.5	0.5	100
7	Commodity trade in retail	1.4	1.9	1.1	0.2	0.2	1.1	49.5	4.3	5.9	0.5	6.0	12.1	7.9	0.2	0.2	1.6	0.8	3.5	1.3	0.3	100
8	Commodity trade merchandise	0.6	1.2	0.6	0.3	0.3	0.9	13.6	34.6	5.4	1.1	3.3	3.5	21.1	1.3	0.6	6.4	2.1	1.5	1.0	0.7	100
9	Transport, warehouse operatives, packers	1.3	2.7	1.7	2.2	0.9	2.3	2.4	3.0	58.0	2.1	2.0	3.5	10.3	1.2	1.2	1.9	1.1	1.0	0.7	0.6	100
10	Personal protection, guards and secutrity occupations	0.3	1.0	0.2	1.0	0.1	0.6	0.6	1.4	3.0	80.0	0.8	0.9	4.0	0.6	0.7	2.5	0.5	0.8	0.1	0.9	100
11	Hotel, restaurant occupation, housekeeping	3.2	2.1	0.9	1.0	0.6	2.3	6.2	2.9	7.4	1.3	47.5	8.5	6.6	0.5	0.7	3.0	1.2	2.4	1.2	0.8	100
12	Cleaning, disposal occupations	1.8	3.0	1.5	1.4	0.6	3.3	2.9	1.2	7.2	1.3	5.3	60.9	2.0	0.4	0.5	2.7	0.4	1.9	1.5	0.4	100
13	Office and commercial services occupations	0.5	0.7	0.4	0.2	0.2	0.5	3.1	5.5	2.6	1.7	1.9	2.1	67.5	1.6	0.7	5.9	1.9	1.4	1.1	0.6	100
14	IT and natural science	0.7	0.5	1.0	0.5	0.2	0.6	0.8	3.0	1.7	0.8	0.9	0.8	7.3	52.2	4.2	13.2	5.2	0.9	0.5	4.9	100
15	Technical occupations	0.9	2.0	7.6	1.6	5.9	5.0	2.5	3.6	5.0	1.4	1.7	2.5	8.2	6.2	33.9	6.8	1.9	1.3	0.7	1.5	100

Table 1 Occupational flexibility matrix from formal vocational qualification to occupation exercised in 2011 for 20 MOF (Continued)

MOF formal vocational qualification	Switches to MOF exercised (in %) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
16 Legal, management and business science	0.4	0.3	0.2	0.2	0.1	0.2	1.3	6.6	1.1	0.8	1.0	0.5	25.1	3.6	0.7	49.3	4.6	0.7	1.0	2.4	100
17 Media, arts and social science	0.4	0.6	0.3	0.5	0.5	0.7	2.3	4.0	1.7	0.7	1.8	1.3	9.9	6.0	1.3	7.8	43.9	1.7	2.8	11.9	100
18 Health occupations	0.4	0.7	0.3	0.1	1.3	0.6	3.3	1.6	1.8	0.5	2.0	3.4	6.5	0.5	0.3	1.5	1.0	71.2	2.2	0.9	100
19 Social occupations	0.4	0.5	0.2	0.1	0.1	0.3	1.6	1.0	1.2	0.4	1.6	2.7	5.0	0.5	0.1	2.4	1.7	3.9	66.4	10.0	100
20 Teaching occupations	0.2	0.2	0.2	0.2	0.1	0.3	0.8	1.3	1.1	0.2	1.2	1.8	3.9	0.9	0.2	1.5	2.5	1.7	3.4	78.4	100
Without formal vocational qualification	3.0	7.8	3.7	4.3	1.7	5.6	7.0	3.1	14.8	1.9	9.9	17.5	7.3	1.2	1.0	2.0	2.2	3.5	1.8	0.8	100
Still in training	2.0	0.8	6.8	3.9	3.3	4.2	7.2	7.0	6.0	1.5	8.6	1.9	15.6	3.7	2.2	1.7	5.2	10.8	4.2	3.5	100

Source: German Mikrocensus 2011, own calculations (BIBB)

and qualification group for the years 2005 to 2011 using Microcensus data. Table 1 shows the aggregate distribution, the so-called flexibility matrix, for the year 2011 for the summarized 20 MOF, where the dark cells highlight the percentage of stayers. Overall, we can see that some groups of persons as distinguished by training OF are more concentrated on fewer exercised OF than others. MOF 20 'teaching occupations' is a classic example of high concentration.

Next, the elasticity δ_2 of Eq. 4 is retrieved, estimating a model of the log share of stayers on the log wage to reference wage ratio, a constant and an error term. We estimate this model using the aggregated flexibility matrices over all age, sex and qualification groups for the 54 OF cross-sections and the years 2005 to 2011. For more robust results we pool OF of similar qualification profiles and historic wage responsiveness together to estimate this model as four separate fixed-effects panel models. Therefore, in each panel all persons associated with a certain training OF react in the same manner to wages in the model. However, the differences in occupational mobility according to age, sex and qualification are accounted for by using the different flexibility matrices for each group in the projection. Panel 1 comprises different OF who have shown high wage responsiveness in the past and consist of high shares of highly educated and very low shares of non-formally qualified workers. Panel 2 includes highly wage responsive OF with a workforce highly centred in the medium but also in the low qualification levels. Panel 3 consists of low wage responsive OF with a similar qualification make-up as panel 2. Finally, panel 4 contains miscellaneous OF with historically very low wage responsiveness.[4]

Table 2 displays the results of the separate panel regressions. Note that we only find an elasticity for 36 of the 54 cases. The remaining cases, as for example 'health-care occupations not requiring a medical practice license', for which no significant elasticity can be found, do not react to wages in the model. In addition, people without any formal qualification are assumed to distribute over exercised OF, in which they comprised at least 3% of the workforce in 2011, according to labour demand, while the distribution over exercised OF of those in education are held constant in the projection.

[4] It is also likely that the structure of the wage data plays a role in this case. The wage data of gainfully employed persons and the legal censorship in the upper income range probably do not represent an ideal measurement, particularly with regard to the OF of 'managing directors, auditors, management consultants' and 'legal occupations'. In the case of 'health-care occupations not requiring a medical practice license', for example, which also show a higher proportion of self-employed persons and a higher income, no positive elasticities can be demonstrated. Nevertheless, because of the absence of a more exact database, it seems appropriate to use the elasticities as given in Table 4 for the baseline projection.

Table 2 Wage elasticitiy of stayers δ by OF (2005–2011)

OF	δ_2
Panel 1: 21 Engineers ǀ 22 Chemists, physicists, scientists ǀ 31 Advertising specialists ǀ 36 Administrative occupations in the public industry ǀ 51 Journalists, librarians, translators, related academic research occupations ǀ 46 Designers, photographers, advertising creators ǀ 24 Technical draughtsmen/draughtswomen, related occupations	2.2
Panel 2: 16 Cooks ǀ 34 Packers, warehouse operatives, transport processors ǀ 40 Auxiliary office occupations, telephone operators ǀ 52 Body care occupations	2.59
Panel 3: 1 Agriculture, husbandry, forestry, horticulture ǀ 2 Miners and mineral extraction workers ǀ 5 Paper manufacture, paper processing, printing ǀ 9 Vehicle and aircraft construction, maintenance occupations ǀ 10 Precision engineering and related occupations ǀ 14 Bakers, pastry cooks, production of confectionary goods ǀ 15 Butchers ǀ 18 Construction occupations, wood and plastics manufacture and processing occupations ǀ 41 Personal protection, guardsǀ 49 Social occupations ǀ 54 Cleaning and disposal occupations	1.27
Panel 4: 6 Metal production and processing ǀ 7 Metal, plant, and sheet metal construction, installation, fitters ǀ 13 Textile processing, leather manufacture ǀ 17 Production of beverages, foods and tobacco, other nutrition occupations ǀ 23 Technicians ǀ 25 Surveying and mapping ǀ 26 Specialist skilled technicians ǀ 27 Sales occupations (retail) ǀ 30 Other commercial occupations (not including wholesale, retail, banking) ǀ 32 Transport occupations ǀ 35 Managing directors, auditors, management consultants ǀ 39 Commercial office occupations ǀ 44 Legal occupations ǀ 53 Hotel and restaurant occupations, housekeeping	0.57

Source: German Mikrocensus and EHD from 2005 until 2011; own calculations

Note that the result that workers and employers of different training occupations and different economic sectors, respectively, do not adjust to changes in the labour market in the same magnitude, conforms to the discussion of Sect. 2: The reallocation process is also subject to influences other than wages. These are (only) implicitly contained in the QuBe model.

However, the comparison of these wage elasticities to results of other studies is limited. The reasons are that (a) these elasticities do not resemble causal effects, but also capture other effects which relate to wages and mobility; and (b) because they are based on the relation of the occupation specific reference wage with the stayer rate (see Eq. 4). Because the reference wage contains also the own wage of each occupation proportional to the historic flexibility, this relation is higher than only looking at outside wages. Therefore, these elasticities are relatively high.

Further, these wage elasticities of the stayer rate are kept constant over the projection period. Departing from this assumption would potentially also relevantly affect the projection outcomes. It is plausible, for example, that technological progress has an impact on the extent to which wages drive mobility decisions. New technologies are suggested to lead to either an increase of complexity of tasks to be performed by workers or a 'deskilling' of tasks, where specialized skills become redundant (cf. Ben-Ner and Urtasun 2013). A change in the skill requirements may lead to a change in mobility behaviour following the reasoning of Geel and Backes-Gellner (2011) and Gathmann and Schönberg (2010). Different outside opportunities may then also translate into a different receptiveness for relative wage changes. In the QuBe model, mainly in favour for keeping the model simple such that results are more transparent, this, however, is not accounted for.

5 Scenario comparisons

In this section, we will display the magnitude of effect of the previously described reallocation mechanism of the QuBe model on the projection outcomes and the practical recommendations based on them. For this purpose, we estimate labour demand and supply for various scenarios concerning a different occupational flexibility behaviour or wage setting assumptions. Firstly, in Sect. 5.1 we demonstrate the overall effect on the projection results from considering versus not considering a reallocation process. Secondly, in Sect. 5.2 we show, which effect can be attributed to the dynamics of worker adjustments with respect to wages. After this, we continue with scenario comparisons to highlight the limitations to wage adjustments in resolving labour shortages in the QuBe model and by that the importance of other determinants for occupational mobility, which are only implicitly modelled. We show that these limitations have a meaningful impact on the deduction of recommended actions to alleviate occupation-specific labour shortages. For this purpose, thirdly, in Sect. 5.3 we show how the economic environment of the employer matters for the result of different wage setting policies and the feasibility of such wage scenarios according the the QuBe model. Lastly, in Sect. 5.4 we complement the previous result by deriving the *optimal* stayer rates for the occupations and

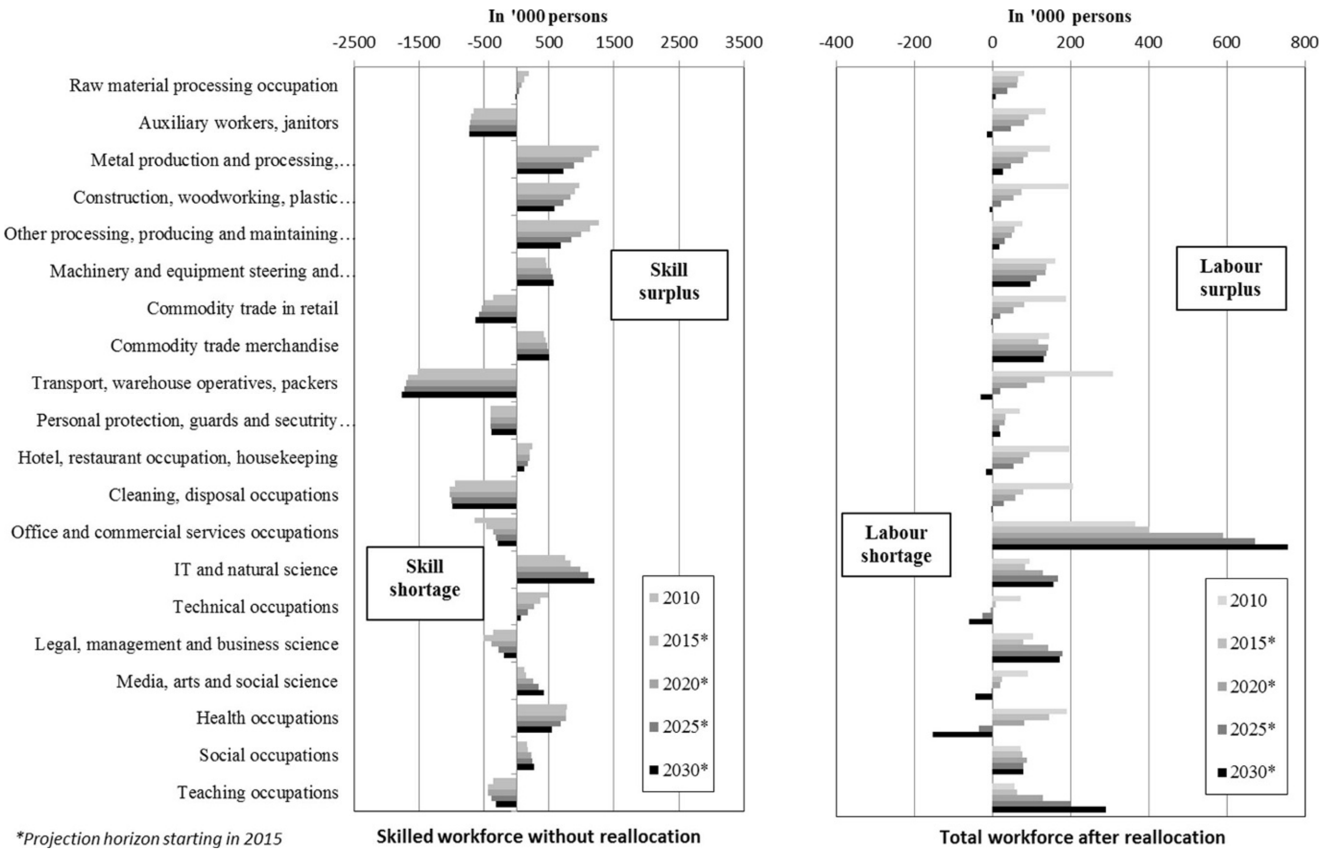

Fig. 2 Skill shortages and surpluses with and without reallocation in 2005–2030. Source: QuBe project 3rd wave; own calculations

discuss to what extent these stayer rates are achievable by the means of wage policies. Note that throughout the following section, we implement the scenario assumptions on the level of the 54 OF. However, for a better visualization the results are always presented on the level of the 20 MOF.

5.1 Implementing occupational flexibility

To start with, Fig. 2 illustrates the effect of implementing a reallocation process by comparing the projection results of the QuBe baseline scenario (right hand side) with a scenario, in which workers were not allowed to switch and employers could not substitute skilled for unskilled or workers from different disciplines (left hand side). In the latter scenario, the projection results suggest that vast labour shortages are possible in 9 out of the 20 MOF. According to this, for 8 of these MOF shortages should have actually already been visible in 2010. In 2030 the deficit would grow to about 4.9 million skilled workers in this scenario. In comparison, taking the reallocation mechanism into account balances the labour market in all but 4 of these occupations; however, shortages appear until 2030 in 5 additional MOF.

Interestingly, now shortages could become especially imminent in the MOF 15 'Technical occupations' and the MOF 18 'Health occupations'. The technicians are frequent movers with a stayer share of only 33.9% (cf. Table 2) and are able to find work in a lot of different MOF. Also, the supply of skilled technicians is decreasing strongly until 2030 (see the decreasing surplus in the left hand graph over time) due to demographic change and retirement of the so-called 'baby boomers', who are more often trained in a manufacturing or technical occupation than younger cohorts.

The health occupations, however, face another problem: Workers in this field are to a great extent loyal to their occupation as indicated by their stayer rate of 71.2% (cf. Table 2). Here as well, not enough workers are being trained in this field (again note left hand graph), while the demands are increasing due to the ageing of the population (Maier and Afentakis 2013).

Ultimately, the total deficit in the baseline scenario is 0.3 million workers only, thus, revealing the substantial impact of a reallocation mechanism on the projection results. Therefore, not taking the empirically verifiable occupational mobility into account at all would exaggerate possible future shortages.

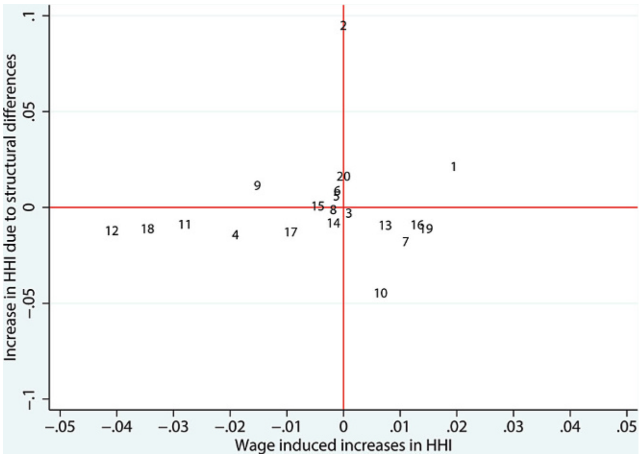

Fig. 3 Differences in HHI due to structural change (2030–2011) and wage development (‘no wage response’ vs. ‘baseline’). Source: QuBe project 3rd wave; own calculations

5.2 Implementing flexibility dynamics

Next, we will further analyse how the wage dynamics of occupational mobility as implemented in the baseline scenario of the QuBe model impact the projection results. For this purpose, consider a world, in which workers did not respond to wage changes, even if they occurred in occupations in which they could have very likely also found work and profited from a wage gain. Thus, in such a world the probability to stay and switch are time invariant. However, note that aggregate mobility in the occupations does change over time, as the age and qualification composition of the workforce changes due to demographic change. Therefore, comparing projection results for such a world with the QuBe baseline scenario enables us to disentangle the effect of wage responsiveness from structural effects.

To visualize the concentration of the workforce, i. e. the possibilities to work with a certain formal vocational qualification in different OF, we calculate the Herfindahl-Hirschman-Index (HHI henceforth; cf. Hirschmann 1964) for the 20 MOF.

$$\mathrm{HHI}_{to} = \sum_{o=1}^{20} \left(\frac{\mathrm{x_o}}{\sum_{o=1}^{20} \mathrm{X_o}} \right)^2 \tag{5}$$

where x_o represents the amount of workers in the exercised MOF o with the training MOF to for which the HHI is evaluated. As there are 20 MOF over which the labour force participants of a training occupation can disperse, HHI $\in [1/20, 1]$, where the minimum value of 0.05 indicates an even distribution over all exercised MOF and the maximum value of 1 indicates perfect concentration on the training occupation.

For the year 2011, the flattest empirical distribution is observed for persons with a formal vocational qualification in the MOF 5 ‘Other processing, producing and maintaining occupations’ (HHI = 0.12). This MOF contains, for example, the textile processors, which have to switch occupations more often as the textile industry in Germany is being downsized. Only persons currently in education (HHI = 0.08) and persons with no vocational training (HHI = 0.09) were more evenly distributed. We found the highest concentration in the MOF 10 ‘Personal protection, guards and security occupations’ (HHI = 0.64). Also the MOF 18 ‘Health occupations’ (HHI = 0.52) and the MOF 20 ‘Teaching occupations’ (HHI = 0.62) are highly concentrated. These 3 MOF have also the highest stayer rates. The mean HHI equals 0.32 weighted by the labour force participants in each training MOF.

In Fig. 3, we now contrast the difference between constant and wage responsive flexibility. On the vertical axis, we plot the pure time trend of the HHI in the 20 MOF, i. e. the HHI in 2011 compared to 2030 of the ‘no wage response’ scenario. On the horizontal axis, we plot the HHI differences in 2030 between the baseline scenario with wage elastic flexibility and that without. Note how shifts along the vertical axis visualize pure structural effects, while shifts along the horizontal line show how the concentration of the workforce on exercised occupations increases or decreases as a result of wage incentives.

Fig. 3 illustrates that concentration hardly changes over time due to changes in the labour force composition. An exception is the MOF 10 ‘Personal protection, guards and security occupations’. This MOF interestingly has the highest HHI in 2011, which, however, is decreased by almost –0.05 units due to structural change only. Note that the other outlier of MOF 2 ‘Auxiliary workers, janitors’ is actually very small in terms of trained labour supply. The wage mechanism of the baseline scenario leads to a higher degree of dispersion over exercised MOF in most training MOF. Wage responses cause the highest reduction in concentration in the MOF 12 ‘Cleaning, disposal occupations’ and the MOF 18 ‘Health occupations’. Here, the projected wage growth fails that of alternative occupations in other MOF leading to higher occupational switching and, therefore, a greater dispersion. Note that the observed effect on the MOF 18 can be purely attributed to a change in dispersion of body care occupations, as doctors and nursing staff do not dynamically respond to wages in the baseline scenario (cf. Table 2). Also note that the MOF 12 and MOF 18 still have some of the highest stayer shares in 2030. In contrast, in the MOF 16 ‘Legal, management, and business science occupations’ or 19 ‘Social occupations’ the wage related increase in concentration level out the dispersion due to structural effects, such that these occupations have almost stable HHIs over time.

The resulting labour demand and supply for each scenario in 2030 can be retrieved from Table 3. It can be

Table 3 Labour demand and supply in 1000 persons by 20 MOF in 2030 in the baseline and 'no wage response' scenario

Main Occupational Field (MOF)		Baseline			'No wage response'		
		Supply	Demand	Diff	Supply	Demand	Diff
1	Raw material processing occupations	907.6	898.6	8.9	929.8	899	30.8
2	Auxiliary workers, janitors	1088.3	1103.6	–15.3	1073	1103.4	–30.5
3	Metal production and processing, installation, electrical occupations	1603.9	1576.5	27.3	1601.7	1575.9	25.8
4	Construction, woodworking, plastic manufacture and processing occupations	1442.2	1451.1	–8.9	1466.8	1450.6	16.2
5	Other processing, producing and maintaining occupations	848.4	831.9	16.4	858.2	831.7	26.4
6	Machinery and equipment steering and maintainance occupations	1772.2	1675.1	96.9	1890	1674.8	215
7	Commodity trade in retail	2056.5	2059.7	–3.2	1968.5	2058.1	–89.5
8	Commodity trade merchandise	2154.4	2024.3	130.1	2213.5	2023.8	189.7
9	Transport, warehouse operatives, packers	3165.1	3194.6	–29.5	3038.8	3194.2	–155.2
10	Personal protection, guards and security occupations	677.5	657.6	19.9	681.3	657.6	23.7
11	Hotel, restaurant occupation, housekeeping	2158.3	2176	–17.6	2079.3	2170.5	–91.1
12	Cleaning, disposal occupations	2051.7	2052.8	–1.1	2004.4	2052.6	–48.3
13	Office and commercial services occupations	6301.3	5545.5	755.8	6479.6	5548.7	931
14	IT and natural science	2369.6	2214	155.6	2390.5	2213.7	176.7
15	Technical occupations	1188.7	1249.2	–60.6	1152.6	1248.9	–96.4
16	Legal, management and business science	2850.8	2679.1	171.7	2811.6	2678.9	132.6
17	Media, arts and social science	1747.9	1792.9	–44.9	1740	1792.2	–52.1
18	Health occupations	3863.7	4016.6	–152.9	3847.9	4027.3	–179.5
19	Social occupations	1739.5	1662	77.4	1737	1662.6	74.4
20	Teaching occupations	1790.6	1500.3	290.4	1813.8	1501.6	312.2

Source: QuBe project 3rd wave; own calculations

observed that without accounting for wage responsive flexibility behaviour, the total deficit equals about 740,000 persons. This is more than twice the deficit of the baseline scenario with dynamics, which amounts to only 340,000 persons. Thus, 400,000 workers, which would be unemployed in other surplus occupations in the projection, are redistributed to the shortage occupations where wages are rising in the baseline scenario.

However, in the MOF 4 'Construction, woodworking, plastic manufacture and processing occupations' the labour market actually gets tighter due to wage dynamics. Here, although the wage responsiveness of flexibility is actually not too high, the projected development of the outside wage options induces the workforce to switch more often to other occupations. In this case, the possibility of a future labour shortage may be understated when dynamic behaviour in occupational flexibility is not accounted for. Ultimately, we can conclude that assumptions about the wage responsiveness of labour mobility are crucial for assessing possible future labour market outcomes.

5.3 The limitations to wage adjustments

We now examine the impact of wage policies in greater detail and point out the importance of their limitations in the QuBe model for the interpretation of results. Shortages are partly projected, due to inferior wage developments in these occupations. Because outside wage opportunities are growing more strongly than in the own training OF, workers – where empirically verifiable – more often decide to switch occupations. Employers can take advantage of this by raising wages in occupations where labour is scarce. However, they are (depending on the industry) constraint by price competition with firms abroad and consumer demand. This is reflected in the QuBe model. To show to what extent employers can strategically use wage adjustments in this model, we implement further wage increases for shortage occupations (as singled out by the baseline projection results). We consider a scenario, where wage growth in the shortage occupations is increased by 10% until 2030 compared to the baseline wage development. Note that this represents an increase of a little more than 0.5% every year until 2030 on top of the projected wage growth of the baseline scenario. Since this represents a relatively small change, in

Table 4 Labour demand and supply in 1000 persons by 20 MOF in 2030 in baseline model and different wage scenarios

Main Occupational Field (MOF)		Baseline			'10%-increase'			'20%-increase'		
		Supply	Demand	Diff	Supply	Demand	Diff	Supply	Demand	Diff
1	Raw material processing occupations	907.6	898.6	8.9	906	895.6	10.4	904.5	892.6	11.9
2	Auxiliary workers, janitors	1088.3	1103.6	–15.3	1090	1097.8	–7.7	1091.6	1092.4	–0.8
3	Metal production and processing, installation, electrical occupations	1603.9	1576.5	27.3	1602.1	1564.7	37.4	1600.1	1553.4	46.7
4	Construction, woodworking, plastic manufacture and processing occupations	1442.2	1451.1	–8.9	1448.4	1433.8	14.6	1453.9	1417.6	36.3
5	Other processing, producing and maintaining occupations	848.4	831.9	16.4	843.5	826.5	17.1	839.2	821.3	17.9
6	Machinery and equipment steering and maintainance occupations	1772.2	1675.1	96.9	1767.5	1663.3	104.2	1763	1652	110.9
7	Commodity trade in retail	2056.5	2059.7	–3.2	2047.1	2029.9	17.2	2037.5	2001.9	35.6
8	Commodity trade merchandise	2154.4	2024.3	130.1	2152.2	2010.2	142	2150.2	1996.6	153.6
9	Transport, warehouse operatives, packers	3165.1	3194.6	–29.5	3170.2	3176.3	–6.2	3174.1	3159.3	14.8
10	Personal protection, guards and secutrity occupations	677.5	657.6	19.9	681.5	660.1	21.4	685.3	662.2	23
11	Hotel, restaurant occupation, housekeeping	2158.3	2176	–17.6	2111.9	2094.7	17.2	2071.4	2024.6	46.8
12	Cleaning, disposal occupations	2051.7	2052.8	–1.1	2045.6	2029.1	16.6	2038.9	2007	31.9
13	Office and commercial services occupations	6301.3	5545.5	755.8	6296.2	5538.6	757.6	6291.8	5531.5	760.3
14	IT and natural science	2369.6	2214	155.6	2361.4	2207.1	154.3	2353.4	2200.4	153
15	Technical occupations	1188.7	1249.2	–60.6	1202.6	1243.1	–40.4	1214.1	1237.2	–23.1
16	Legal, management and business science	2850.8	2679.1	171.7	2849.6	2667.8	181.8	2848.8	2657.1	191.7
17	Media, arts and social science	1747.9	1792.9	–44.9	1766.1	1789.2	–23.1	1782.7	1785.2	–2.5
18	Health occupations	3863.7	4016.6	–152.9	3899.6	4017	–117.4	3933.5	4016.4	–83
19	Social occupations	1739.5	1662	77.4	1740.3	1673	67.3	1741.9	1683.2	58.7
20	Teaching occupations	1790.6	1500.3	290.4	1796.3	1513.6	282.7	1802.2	1526	276.2

Source: QuBe project 3rd wave; own calculations

a second scenario we increase wage growth in the shortage occupations by 20%, i. e. an additional increase of a little more than 1% every year until 2030. The results are presented in Table 4.

The results show (cf. Table 4) that with a wage increase of an additional 10% until 2030 for shortage occupations, labour shortages will be reduced by about 140,000 persons in 2030, so that the total deficit in this scenario equals 195,000 persons. Shortages could be prevented in 4 of the 9 shortage MOF of the baseline scenario, namely in the MOF 4 'Construction, woodworking, plastic manufacture and processing ocupations, MOF 7 'Commodity trade in retail', MOF 11 'Hotel, restaurant occupation, housekeeping', and the MOF 12 'Cleaning, disposal occupations'. Looking at the results, of the 20% increase in wage growth for baseline shortage occupations, the total deficit of labour supply equals about 115,000 persons, which is a reduction by even 225,000 persons compared to the baseline scenario. However, the labour market is balanced in only one additional MOF compared to a 10% increase until 2030, namely the MOF 9 'Transport, warehouse operatives, packers'. We can see that the balance in these MOF is mainly achieved by a reduction in labour demand. Since labour productivity remains unchanged, note that this corresponds to a reduction in production or service provision, respectively. In these occupations, outside price pressures are too high, such that large wage adjustments are infeasible for employers without reducing their output. Here, it is more realistic that alternative strategies would be used to retain workers or workers would be hired from abroad to keep the wage level low.

The other shortage MOF, for which a shortage is projected until 2030 even after an additional wage increase of 20%, are the MOF 2 'Auxiliary workers, janitors', MOF 15 'Technical occupations', MOF 17 'Media, arts and social

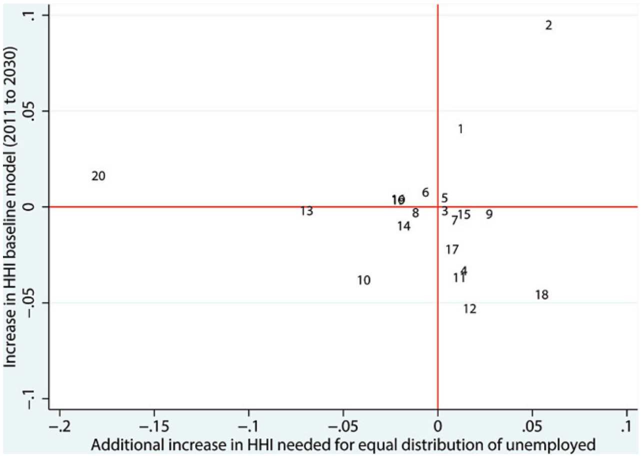

Fig. 4 Needed adjustments of occupational flexibility to achieve equal unemployment rates in 2030. Source: QuBe project 3rd wave; own calculations

science occupations', and MOF 18 'Health occupations'. In all of these MOF, demand remains relatively stable, suggesting that here price pressures are less dominating, because production or service provision cannot simply be reduced. We leave the MOF 2 out of the discussion as they comprise a very small group of people and are not associated with dynamic behaviour in the QuBe model mainly due to data restrictions. The MOF 15 and 17 have comparably lower stayer rates of 39% and 43%, respectively, because their labour can be applied in very diverse fields. Here, the deficit is more severe in the MOF 15, mainly because workers trained in this field react much less to wage impulses. Most of the occupations in MOF 17 are attached with a wage elasticity of 2.2 in the baseline scenario, indicating that career seeking is a major determinant in the occupational flexibility behaviour of journalists, designers etc. In contrast, most of the occupations in the MOF 15 only react to wages with an elasticity of 0.57, suggesting that here other factors as for example better working conditions may strongly influence mobility decisions.

In the MOF 18 it is only the body care occupations, which react to wage impulses. Increasing wages cannot reduce the shortage of doctors and nursing staff, because the baseline QuBe projection reflects that their fairly high occupational loyalty is not significantly driven by wage incentives. Also, a wage increase in these occupations does not considerably raise the inflow of labour supply into these occupations from other fields, which simulates the effect of strong working regulations concerning qualifying credentials and approbations (see also Pollmann-Schult 2006).

Overall, we can conclude here that accounting for the limitations to wage setting policies within the projection model has significant impacts on the feasibility of scenarios aimed at overcoming shortages. This has important consequences for policy consulting and enhances the credibility of practical advice based on calculations of a projection model.

5.4 The 'optimal' flexibility

In the following, we examine, what kind of adjustments in the occupational flexibility behaviour would be needed to distribute unemployed workers evenly and to overcome labour shortages in every OF in 2030. Thus, this scenario entails a redistribution of the labour supply from surplus to shortage occupations. Also looking at the results from the previous section, we assess how wages can serve to achieve the resulting differences in the stayer rate according to the assumptions of the baseline scenario.

Technically, we apply a RAS procedure. The RAS algorithm (cf. Bacharach 1970; Leontief 1951) is an iterative method of biproportional fitting of matrices, which is used to estimate elements of an unknown matrix based on known row and column sums and an initial estimate of the matrix. Transferred to this exercise, the RAS algorithm fits the cells of the flexibility matrix of 2030, such that column totals, i. e. labour supply in the exercised OF, are such that in every OF an equal unemployment rate is achieved. In doing so, the algorithm loops over occupations – starting with that with the highest unemployment rate – and redistributes the difference between the baseline surplus supply and that needed to achieve the targeted unemployment rate to other occupations. The reallocation is proportional to the initial flexibility matrix of the baseline scenario, such that workers trained in surplus occupations switch more (have a smaller stayer rate); however, to the same extent into the same exercised occupations.

Fig. 4 visualizes the change in flexibility again using differences in the HHI indicating growing or declining concentration in the MOF. Here, the difference in the HHI between 2011 and 2030 in the baseline projection is plotted on the vertical axis against the HHI difference between the 2030 workforce of the baseline projection and the scenario using the optimal occupational flexibility matrix on the horizontal axis. MOF plotted to the left (right) of the 0 benchmark on the horizontal axis, indicate a need for a higher (lower) flexibility as compared to the baseline assumptions in order to clear the labour market in 2030.

Overall, the majority of the MOF actually should be more flexible in order to correspond optimally to labour demand. Especially, persons in the MOF 20 'teaching occupations' but also the MOF 13 'office and commercial services occupations', for which vast surpluses are projected due to demographic change and a rising educational attainment in these occupations, should more often consider switching their occupation in the future. In the MOF 20, the share of stayers would have to be reduced from 79.4 to 66.6% in 2030. In the MOF 13 a reduction of the share of stayers to 61.6% from its level of 67.2% in the baseline projection in 2030 would be needed. Note that this MOF also contains the public administrates, which mainly drive this result, here. They alone would need a reduction of the stayer ratio by more than 12 percentage points. However, in both of these MOF, workers do not react to increases in outside wages in the QuBe model and are very loyal to their training occupations (cf. Table 1 and 2). This poses a challenge of achieving such a reduction in stayer rates. Likely, this could not be accomplished by increasing wages in related fields, as other underlying factors as for example work place stability or reconciliation of family and work are stronger motivators for high stayer rates in these occupations.

In contrast, persons trained in the MOF 18 'Health occupations' would need to stay in their occupation more often. The projected stayer rate of 67.8% in 2030 in the baseline scenario would have to increase to 71.9%. This complements the results of the previous section: Because switches into these occupations are quite unlikely due to work regulations, the needed increase in stayers would only be achievable via an even greater occupational loyalty or increased training of new supply. Since outside wages are not significantly important to doctors and nursing staff, the results again stress the impact of other factors, as for example working conditions, on making these occupations more attractive for policy recommendations to realize the increase in labour supply.

Interestingly the shortage MOF 15 'Technicians', would hardly need any flexibility adjustments at all according to this calculation. Their optimal flexibility would entail a stayer share of 35.7% in 2030. Therefore, the adjustment from its baseline value of 33.2% would amount to merely 2.5 percentage points. Here, the redistribution from surplus fields is high enough such that only a small adjustment in the stayer rate suffices to balance the submarket for technicians. We find that almost 70% of the additional workforce in this MOF would be recruited from outside (mainly engineers and electrical occupations). Here, wage policies may serve to attract workers from related fields to some extent, however the persisting shortages even after large wage increases (cf. Sect. 5.3) suggest that again working conditions in this field may be more promising to target.

In summary, for an optimal distribution of unemployed workers over the exercised occupations, stayer rates for many training occupation would have to differ. As already discussed in the previous section, wages are often an infeasible tool to reach the optimum, here. In the QuBe model, alternative determinants for occupational mobility are important for the interpretation of the results, although they are only implicitly accounted for. In the end, this is essential for deriving recommendations for practical actions, which most often is the ultimate aim of long-term labour market projection.

6 Conclusion and discussion

In this paper, we discuss and illustrate the necessity of implementing a dynamic reallocation process of labour supply into labour market projections and how the underlying assumptions strongly influence the plausibility of the projection results and their interpretation for policy consulting. Long-term projections have become very popular for guidance in political decision-making. Therefore, it is essential that the model set-up reflects country-specifics and can draw a plausible image of the possible future developments. In Germany, therefore, it is essential that a projection model (a) represents the occupational dimension of the German labour market and (b) reflects the extent to which workers skilled in different occupations can be substituted for each other (Helmrich and Zika 2010). These two aspects are essential for an assessment of possible reallocations of labour supply in respond to imminent shortages.

The BIBB-IAB qualification and occupational field projections (Maier et al. 2014) is to our knowledge the only long-term projection model, which explicitly formulate such a reallocation process. In this model, the central link between demand and supply is wages: Employers raise wages in shortage occupations to make work in these fields more attractive and workers react to relative changes in their outside wage opportunities and adjust their intent to stay. The great degree of detail of the model by 63 economic sectors and 54 occupational fields provides a thorough description of the diverse adjustment behaviours of different groups of market participants. In this way, the projection results also implicitly capture reallocation behaviours, which are not driven by wage and scarcity, respectively.

Our results show that not accounting for occupational flexibility at all, i. e. not modelling any reallocations in the labour market, would project vast shortages of almost 5 million skilled workers in 9 of the 20 main occupational fields in 2030. Compared to this, the baseline scenario, which accounts for dynamic adjustments on both sides, would only project a total deficit of about 340,000 workers in 2030. However, the reallocation process can be directly linked to shortages, which now appear in 'health occupations' and 'technical occupations'. In both of these main occupational fields inflows from other fields would not suffice to balance out the outflows of skilled workers to other related fields.

Next, looking at the effect of dynamic adjustments of the flexibility behaviour of workers, we compare the baseline scenario to a scenario, where shares of stayers do not respond to wages. We find that dynamics can account for a difference in the deficit of labour supply of about 400,000 people in 2030. Shortages in the 'Construction, woodworking, plastics manufacture and processing occupations' actually become more severe in the projection results after considering a dynamic adjustment of workers. Here, wage dynamics reflect the tension between price and employer competition for labour supply.

Furthermore, we illustrate how also the limitations to wage dynamic adjustments as captured by the QuBe model influence the interpretation of results and the derived recommendations for practical actions. For this, we look at the effect of different wage policies. We compare a 10% and a 20% increase of wages until 2030 for shortage occupations. We see that in the QuBe model these wage increases would be able to balance some occupational submarkets, however, mainly by a reduction of labour demand and, thus, a lower production or service provision in the economy. For the remaining shortage occupations in these scenarios, we discuss how wages as a policy tool simply are not effective given the QuBe assumptions about wage dynamics of occupational mobility. Especially for technicians, doctors, and nursing staff other factors related to working conditions may be more important for political actions. In the case of health occupations, also working regulations play an important role, which limits the extent to which workers from outside can be recruited for this field.

We complement these results further, by calculating the 'optimal' flexibility of the workforce, which would evenly distribute unemployed workers over the occupations. We find that most of the workforce would have to be more flexible. In contrast, health personnel would need to stay more often within their training occupation. As they do not respond to wages empirically, again working conditions but also increased training of new supply may be more feasible policy implementations. Surprisingly, in the case of technicians no large adjustment of mobility behaviour would be needed, because also an increased inflow of workers from related fields would help to balance out deficits of labour supply. In this field, the sufficient provision of labour supply may be achieved, both to their own extent, by increasing wages and improving work conditions, but also by providing persons with related educational backgrounds further educational training to enhance specific needed skills.

The results illustrate how for the derivation of plausible policy recommendation also the limitations to reallocations are central to modelling. Based on the QuBe model, however, we can only discuss the relative importance of other driving factors of occupational mobility in light of the restrictions of the wage dynamics. Therefore, also integrating, for example, working conditions into long-term labour market projection models may be an intriguing field of further studies. Furthermore, throughout our analyses we assume that the response of workers to outside wages in their mobility decisions is time invariant. Here, as well different set-ups where for example dynamics evolve subject to technological progress are possible and maybe a fruitful field for research. However, when advancing model set-ups in these ways, the transparency of results has to always be kept in mind as well (c.f. Wilson 2001).

Lastly, in the discussed model, the potential of the offered amount of hours by the labour force has been assumed to be stable during the projection period (Zika et al. 2012). Furthermore, it is assumed that participation rates follow an increasing trend and migration inflow to Germany is kept constant according to the 12th Coordinated Population Forecast of the Federal Statistical Office. Of course, these measures could in principal also work as dynamic mechanisms in long-term labour market projections. In fact, this may work better for employers in occupations with strong wage setting constraints and workers in occupations with low wage responsiveness. As this has not been done thus far, in future studies it would be very interesting to assess the differences in projection results and policy advice between obtained from projections using these different mechanisms.

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Appendix

Table 5 Major Occupational Fields (MOF) and Occupational Fields (OF)

MOF		OF	
1	Raw material processing occupations	1	Agriculture, husbandry, forestry, horticulture
		2	Miners and mineral extraction workers
2	Auxiliary workers, janitors	20	Auxiliary workers without further specified task
		42	Janitors
3	Metal production and processing, installation, electrical occupations	7	Metal, plant and sheet metal construction, installation, fitters
		11	Electrical occupations
4	Construction, woodworking, plastic manufacture and processing occupations	18	Construction, woodworking, plastics manufacture and processing occupations
5	Other processing, producing and maintaining occupations	3	Stoneworking, construction materials production, ceramics and glass related occupations
		9	Vehicle and aircraft construction, maintenance occupations
		10	Precision engineering and related occupations
		13	Textile processing, leather manufacture
		15	Butchers
6	Machinery and equipment steering and maintainance occupations	4	Chemical and plastics occupations
		5	Paper manufacture, paper processing, printing
		6	Metal production and processing
		8	Industrial mechanics, tool mechanics
		12	Weaving occupations, textile manufacturers, textile finishers
		17	Production of beverages, food and tobacco, other nutrition occupations
7	Commodity trade in retail	27	Commodity trade in retail
8	Commodity trade merchandise	28	Wholesale/retail service occupations
		30	Other commercial occupations (not including wholesale, retail, banking)
9	Transport, warehouse operatives, packers	19	Goods inspectors, dispatch, processing operators
		32	Transport and logistics occupations
		33	Aviation, shipping occupations
		34	Packers, warehouse and transport occupations
10	Personal protection, guards and secutrity occupations	41	Personal protection, guards
		43	Security occupations
11	Hotel, restaurant occupation, housekeeping	14	Bakers, pastry cooks, production of confectionary goods
		16	Cooks
		53	Hotel and restaurant occupations, housekeeping
12	Cleaning, disposal occupations	54	Cleaning and disposal occupations
13	Office and commercial services occupations	29	Banking and insurance professionals
		36	Administrative occupations in the public sector
		37	Finance, accounting, bookkeeping
		39	Commercial office occupations
		40	Auxiliary office occupations, telephone operators
14	IT and natural science	21	Engineers
		22	Chemists, physicists, scientists
		38	Core IT occupations

Table 5 Major Occupational Fields (MOF) and Occupational Fields (OF) (Continued)

MOF		OF	
15	Technical occupations	23	Technicians
		24	Technical draughtsmen/draughtswomen, related occupations
		25	Surveying and mapping
		26	Specialist skilled technicians
16	Legal, management and business science	35	Managing directors, auditors, management consultants
		44	Legal occupations
17	Media, arts and social science	31	Advertising specialists
		45	Artists, musicians
		46	Designers, photographers, advertising creators
		51	Journalists, librarians, translators, related academic research occupations
18	Health occupations	47	Healthcare occupations requiring a medical practice licence
		48	Healthcare occupations not requiring a medical practice licence
		52	Body care occupations
19	Social occupations	49	Social occupations
20	Teaching occupations	50	Teaching occupations

Table 6 Structure of the NACE Rev. 2 Classification of Economic Activities used in the Projection

	Divisions of the economic sectors (collated)
1	Agriculture
2	Forestry
3	Fishing
4	Mining, extraction of stones and earth
5	Manufacture of food and drink, tobacco processing
6	Manufacture of textiles, clothing, leather goods and shoes
7	Manufacture of wood, wicker, basket and cork goods (not including furniture)
8	Manufacture of paper, cardboard and of paper and cardboard products
9	Manufacture of printing products, reproduction of sound, picture and data storage media
10	Manufacture of coke and refined petroleum products
11	Manufacture of chemical products
12	Manufacture of pharmaceutical products
13	Manufacture of rubber and plastic products
14	Manufacture of glass products, manufacture of ceramics, processing of stones and earth
15	Metal production and processing
16	Manufacture of metal products
17	Manufacture of computer, electronic and optical products
18	Manufacture of electrical equipment
19	Engineering
20	Manufacture of motor vehicles and motor vehicle components
21	Other vehicle construction
22	Manufacture of furniture and other goods
23	Repair and installation of machines and equipment
24	Energy supply
25	Water supply
26	Sewage, waste disposal, materials recovery
27	Construction sector
28	Motor vehicle trade, maintenance and repair of motor vehicles

Table 6 Structure of the NACE Rev. 2 Classification of Economic Activities used in the Projection (Continued)

	Divisions of the economic sectors (collated)
29	Wholesale (not including the motor vehicle trade)
30	Retail (not including retail of motor vehicles)
31	Land transport and transport in pipelines
32	Shipping
33	Aviation
34	Warehousing, other transport service providers
35	Post, courier and express services
36	Hotel and restaurant trade
37	Publishing
38	Audiovisual media and radio
39	Telecommunications
40	IT and information service providers
41	Financial services providers
42	Insurance and pension funding
43	Activities associated with financial and insurance services
44	Real estate
45	Legal and tax consultancy, management consultancy
46	Architectural and engineering companies, technical support
47	Research and development
48	Advertising and market research
49	Freelance, scientific, technical services (not mentioned elsewhere), veterinary medicine
50	Renting of mobile goods
51	Placement and hiring of workers
52	Travel agencies and tour operators
53	Service providers (not mentioned elsewhere)
54	Public administration, defence, social security
55	Education and teaching
56	Healthcare system
57	Residential homes and social services
58	Art and culture, gambling
59	Sport, entertainment and recreation
60	Lobbying, religious associations
61	Repair of computers and used goods
62	Other providers of mainly personal services
63	Housekeeping services

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