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Labour shortages and replacement demand in Germany

The (non)-consequences of demographic change

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Contents

Abstract

Two stylised facts of the German labour market are that first, the demand for high-skilled labour has been growing rapidly for a number of years and second, the country is facing a particularly strong demographic change with the expected size of the population decreasing rapidly and the average age of the labour force increasing sharply. This has led to a widely discussed fear of "labour shortages". One of the reasons often stated in the public debate is that within a given time period many more old individuals are retiring than young individuals are entering the labour market. Although there is a certain logic in this argument, it is only prima facie convincing because firstly, a change in labour demand could counteract this effect and secondly, it is unclear whether – given labour demand for the occupations people retire from – people retiring from the labour market are normally "replaced" by *young* cohorts entering the labour market. Thirdly, even if the size of a cohort differs between generations, it is by no means clear what the effects on labour supply are as, for example, the participation rates may also differ. We address these issues from a theoretical and empirical perspective. In the theoretical part we focus on the relationship between vacancies and unemployment (labour-market tightness) and show that it does not always increase with demographic change. In the empirical part, we analyse how employment is affected over time by different shares of different age cohorts. We find no evidence that a higher number of retirees in an occupation leads to a higher demand for younger workers. Instead, to a large extent, retirees seem to be "replaced", if they are replaced at all, by middle-aged cohorts who change occupations. Thus, we conclude that the interaction between large retiring cohorts and small entering cohorts within occupations is less direct than is suggested in the public debate.

Zusammenfassung

Zwei wichtige Entwicklungen auf dem deutschen Arbeitsmarktes sind, dass erstens die Nachfrage nach hochqualifizierten Arbeitskräften seit einigen Jahren stark gestiegen ist und zweitens, dass sich Deutschland einem besonders raschen demografischen Wandel gegenüber sieht, was sich einerseits darin mainifestiert, dass die erwartete Größe der Bevölkerung rasch sinkt und zweitens das Durchschnittsalter der Bevölkerung rapide ansteigt. Diese Trends haben in Deutschland zu einer Diskussion über Fachkräftemangel geführt. Einer der gerne genannten Argumente in dieser Diskussion ist, dass in den kommenden Jahren viel mehr ältere Menschen in Rente gingen, als neue jüngere in den Arbeitsmarkt eintreten. Obwohl man diesem Argumente eine inhärente Logik nicht absprechen kann überzeugt es nur auf den ersten Blick, weil erstens Änderungen der Bevölkerungsgröße nicht notwendig mit entsprechenden Veränderungen beim Arbeitsangebot einhergehen müssen, weil zweitens unklar ist, ob ältere Kohorten typischer Weise durch jüngere Kohorten ersetzt werden und weil drittens Anpassungen bei der Arbeitsnachfrage Veränderungen beim Arbeitsangebot kompensieren könnten. In diesem Papier adressieren wir die Frage des demografischen Ersatzbedarfs aus theoretischer und empirischer Perspektive. Theoretisch identifizieren

wir Fachkräftemangel mit dem Mindestkriterium, dass sich das Verhältnis von offenen Stellen zu Arbeitslosen vergrößert und zeigen dass das nicht eindeutig für demografische Veränderungen gilt. Im empirischen Teil der Arbeit untersuchen wir, wie die Beschäftigung über die Zeit mit der relativen Größe der unterschiedlichen Alterskohorten zusammenhängt. Wir finden keine Evidenz dafür, dass ein hoher Anteil von älteren Beschäftigten, die den Arbeitsmarkt verlassen, in einem Beruf danach zu einer höheren Nachfrage nach jüngeren Arbeitnehmern führt. Stattdessen findet einen Nachbesetzung – falls sie stattfindet –– typischer Weise eher aus den mittleren Altersgruppen durch Berufswechsler statt. Wir schlussfolgern, dass der Zusammenhang zwischen demografischen Veränderungsprozessen und Arbeitsmarktergebnissen, insbesondere im Hinblick auf das Ersatzbedarf-Argument, viel weniger direkt ist, als häufig in der öffentlichen Debatte angenommen wird.

JEL classification: J11; J21; J26

Keywords: Labour-Market; Demography; Replacement Demand

1 Introduction

Demographic projections for many countries suggest that population ageing is likely to accelerate over the next 50 years. Germany is a particularly interesting country for studying the impact of demographic changes on labour markets. The demographic change in Germany is relatively fast compared to other European countries or the US, for example. In Germany, the relative size of the labour market entry cohorts (the share of those aged 15 to 24 relative to those aged 15 to 64) has been decreasing significantly since the 1980s and is now roughly 10 percentage points lower. According to United Nations (2012), amongst the OECD countries, between 2010 and 2025 only the populations in Japan and Hungary are predicted to decline more rapidly than Germany's.

In addition to these demographic changes in Germany, employment – especially for the high-skilled (i.e. those holding academic degrees) – has been increasing: The number of high-skilled employees increased by around a third in the last 10 years. Thus, it is not astonishing that recently, namely in the aftermath of what Paul Krugman called "Germany's job miracle" (for a discussion see Möller, 2010; Burda/Hunt, 2011), an intensive political debate has resumed, addressing the risk of (skilled) labour shortages in Germany. Some observers argue that the shrinking population size is likely to lead to skilled labour shortages because vacant jobs, especially those of the high-skilled, cannot be filled any more because there are not enough young people to "replace" them. For example, in a study by the Cologne Institute for Economic Research on behalf of the Association of German Engineers (*Verein deutscher Ingenieure (VDI)*), in 2011 there were an average of 72,000 vacancies for engineers which could not be filled. They calculate the economic loss in GDP at roughly 8 billion Euros. Similarly, the biannual publications of the Federal Employment Agency (FEA) on labour shortages in Germany regularly argues that although there is no general labour shortage yet, there are certain occupations which are already affected (Bundesagentur für Arbeit, 2015). These occupations are then candidates for the so called "Positive List" for which immigration barriers are lower.

In the literature the subject of ageing populations is receiving increased attention.[1] The issues addressed include the impact of ageing on growth rates (see, for example Bloom/Canning/Fink, 2010) or productivity (see, for example Bloom/Sousa-Poza, 2013; Mahlberg et al., 2013; Prettner/Bloom/Strulik, 2013; Zwick/Göbel, 2013) and changing patterns of consumption and saving or the implications for the public finances of rising expenditure on pensions, social security, social care, and health care. Focussing on the labour market, D'Addio/Keese/Whitehouse (2010) analyse the general impact of changing effective retirement rates.

In this paper, we analyse the shortage assertion both from a theoretical and from an empirical point of view. As there is no consensus or clear definition on when a "short-

[1] See, for example, the special issue of the Oxford Review of Economic Policy, Volume 26, Number 4 in 2010.

age" actually exists, in the theoretical model we focus on the concept of labour-market tightness, i.e. the ratio of vacancies to unemployed. Hence, the key question is whether demographic changes lead to an increase in labour-market tightness in a new labour-market equilibrium or not. By concentrating on the change of this variable only, we avoid the choice of a necessarily arbitrary tightness threshold level.[2] We discuss the question from the point of view of replacement demand, i.e. we analyse the question whether older cohorts who retire will be "replaced" by smaller younger cohorts. This is one transmission mechanism through which changes in labour supply are thought to transform into shortages. Hence, we address an argument often heard in the debate on labour shortages, namely that: As in a certain occupation in the next years a high number of people will retire, there will be a shortage because there are fewer young people who can replace them.

A number of papers have attempted to estimate replacement demand using a different approach (see, for example, Willems/de Grip, 1993; Shah/Burke, 2001; Fox/Comerford, 2008). Generally, they analyse replacement demand in the context of flow identities, i.e. summing total in- and outflows taking changes in total population size due to births, deaths and immigration into account.[3] This is then used to forecast future replacement demand.

The aim of this paper is first to undermine the replacement demand argument more thoroughly from a theoretical perspective. The question is hence, do firms (want to) replace retiring employees when at the same time the size of the young cohorts entering the labour market is shrinking. Second, using our approach, we are able to answer whether this kind of mechanism has been present in the past where continuously smaller cohorts entered the labour market and thus the effect should – at least if it plays a role – have been observable.

We develop our theoretical argument in the context of a matching model. In line with the replacement-demand argument, we find that a decrease in the number of people entering the labour market lowers equilibrium unemployment. However, the fact that at any given moment in time more people are retiring because the average age of the working population is increasing, does not lead to lower unemployment rates. On the contrary, the fact that the duration of expected job matches decreases means that creating new jobs is now less profitable. In addition, the decrease in the size of the workforce leads to higher wages which further reduces labour demand. Hence, higher retirement rates actually lead to higher unemployment rates. These theoretical findings underline the fact that the replacement-demand argument is too simple as labour-market adjustments are not adequately taken into account.

[2] The German Federal Employment Agency defines a labour-market shortage in an occupation if the average time to fill a vacancy is more than 40 % above average and there are less than 150 registered unemployed (looking for jobs in the occupation) per 100 vacancies or if there are fewer unemployed than vacancies in an occupation. However, at least to a certain extent, these limits are arbitrary as there is no scientific bass to justify them.

[3] More precisely, they differentiate between expansion demand caused by job growth in an occupation and replacement demand which is demand caused by outflows from an occupation.

To test the replacement demand hypothesis empirically, we use aggregated micro data on employment across age groups and occupations for the years 1975 to 2010 to identify people entering or exiting the labour market as well as those who switch occupations during their careers. In addition, we also analyse the hypothesis of Freeman (2006), who asserts that occupations with a high share of old individuals are growing more slowly, i.e., we test whether employment in occupations which are heavily affected by retirement is decreasing faster, at the same speed or more slowly than market segments which are not strongly affected by retirement.[4] First, we find that occupations with a high share of older persons in Germany do not grow more slowly or faster than other occupations. Thus, it does not seem to be the case that "old occupations" on average are those occupations that vanish. Second, we provide evidence that across occupations the young cohorts are unlikely to actually replace the old cohorts. Large exiting cohorts in an occupation are not accompanied by many youngsters in this profession afterwards. However, we show that in the case where large exiting occupational cohorts are replaced, this is likely to be accomplished by the middle aged cohorts. We find them significantly more often in these occupations, when a few years before there has been a large old cohort. We interpret these results as pointing to the significance of occupational changes, since we control for the size of this group in the same occupation a few years before.

We further analyse whether market conditions as driven by demographic changes explain occupational changes. More precisely, we show that job terminations in general and occupational changes in particular are less likely to occur when the market segment is affected by heavy retirement. In addition, we provide evidence that the middle-aged cohorts reaction on market condition is strongest, confirming our results from the above analysis. This further points to the significance of occupational changes as adjustment mechanism as is stressed in our theoretical model. We also analyse whether more persons choose a certain profession when there are large exiting cohorts and whether we can find evidence that this affects their career outlook.

Our findings stress the importance of occupational mobility as compared to the significance of the vocational training choice. From our results it is not clear that young people should be advised to choose occupations with a large replacement demand, i.e. occupations with large exiting cohorts as job opportunities for the young do not seem to be (directly) related to this. This is even true for growing occupations.

2 Theoretical Considerations

In a neoclassical setting, typically, changes in population size translate into changes of labour supply, wages and respective changes in employment. For example, a decrease in labour supply *c.p.* leads to a higher wage. Although total employment decreases as a result, the labour market still clears and at market wages there is no demand which is not met by supply. Thus, unfulfilled replacement demand whereby

[4] This could be seen as an alternative hypothesis to the replacement demand hypothesis.

it is not possible to replace older workers with younger ones does not occur. In the new equilibrium, firms can hire as much labour as they demand and there is no "shortage" of any type of labour. Hence, in order for the replacement demand argument to hold in theory, the labour market must be imperfect to some extent. Obviously the same is true for the existence of unemployment. A typical neoclassical setting has difficulties in accounting for unemployment. Note however, that there is an important difference between unemployment and labour shortage: while it is easy to think of unemployment as being caused by rigid wages that are too high and – for some reason – cannot be adjusted downward (see e.g. the literature on (downward) wage rigidity Knoppik/Beissinger 2009), it is much harder to think of wages as being too rigid upwards. To the best of our knowledge, the literature has not been successful in bringing up arguments for upward wage rigidity.[5]

As can be seen for example in Shah/Burke (2001) or Fox/Comerford (2008), replacement demand in a pure flow equilibrium implies – ignoring employment expansion or decline – that all outflows from an occupation must be replaced by an equal number of inflows. Hence, to obtain such a result in a theoretical setting when the population is ageing and there are more people retiring than entering the labour-force population, the model would need to imply that neither wages nor labour demand, nor labour supply (in the long run) adapt to the increasing number of outflows.

Labour market imperfections are obviously not an unrealistic assumption. However, even taking this fact into account, from our point of view, there are not many labour-market theories which support a replacement demand argument. One possibility to think of replacement demand is the existence of some kind of sluggish adjustment towards a new equilibrium in reaction to demographic changes. Such adjustment occurs for example, in models of dynamic labour demand, where firms have difficulties in *reducing* their labour due to firing costs (see, e.g. Hamermesh, 1993). With regard to the demographic changes which we analyse here, however, firing costs do not play a key role as the workers are retiring voluntarily. Hence, in our context, if firms are "slow" in adapting to changes in labour demand, but at the same time an increasing number of new workers should be hired because more current workers are retiring, then they would be hiring fewer workers than is optimal. But this is the exact opposite of unfulfilled replacement demand.

Firing costs also play a crucial role in "insider-outsider" models (see Lindbeck/Snower, 2001). Again: in the case of replacement demand these are not highly relevant. These models also help explain wage rigidities. However, in our context where demographic changes are likely to lead to a reduction of labour demand, equilibrium requires increasing, rather than decreasing wages. Hence, downward wage rigidities are unimportant.

Modern labour market theory is often based on a matching model. In this framework,

[5] While it is true that implicit or explicit contracts (see e.g. Malcomson, 1999) might also prevent wages from adjusting upwards, this literature does not yield arguments for a disequilibrium on the labour market, caused by demographic trends. The contracts insure individuals against fluctuations and are not long-term.

imperfect information leads to market frictions that generate outcomes that deviate form the neo-classical supply-demand result. However, as in the standard neo-classical model, the size of the labour force plays no role for (un-)employment rates in the basic matching model (Pissarides, 2000: Chap. 2) as firms adapt their labour demand (i.e. vacancies) accordingly. The approach we choose to demonstrate the effects of population ageing and decreasing population size is based on the matching model in Pissarides (2000: Chap. 4). We extend the model by explicitly taking different retirement rates from unemployment and employment respectively into account. This is important from our point of view, since, empirically the retirement decision clearly depends on the labour market status of a person at the age of retirement.

We assume an exogenous job-destruction rate λ. Denoting the total labour force by L and the unemployment rate by u, the number of workers who loose their jobs in a given period of time is $\lambda(1-u)L$. In addition, people are assumed to quit their jobs to look for another job at the (exogenous) rate λ_0. Further, there is a flow of new entrants bL who first start as unemployed when they enter the labour force. In the basic model in Pissarides (2000: Chap. 4), the retirement rate d from both unemployment and employment is the same. With an ageing population, this rate is expected to increase in the future as at any given moment in time, a larger proportion of the labour force retires.[6] In our model, we distinguish the retiring rate out of employment d_e and out of unemployment d_u. The increasing overall exit rate from the labour market to retiring is however thought to show up in both the exit rates out of employment and out of unemployment.

The number of workers who find new jobs in the (small) time interval dt is given by $q(\theta)\theta uLdt$ where $\theta = v/u$ is the relationship between vacancies and unemployed and is thus an indicator for labour-market tightness. We assume for the moment that $d_u = d_e = d$. Hence, labour-market flows are:

$$\frac{d}{dt}uL = (\lambda + \lambda_0)(1-u)L + bL - duL - q(\theta)\theta uL$$

Noting that

$$\frac{d}{dt}uL = \frac{d}{dt}u + \frac{d}{dt}L = \dot{u}L + u\dot{L}$$

it follows that $\dot{u}$ the change in the unemployment rate over time evolves according to

$$\dot{u} = (\lambda + \lambda_0)(1-u) + b - du - q(\theta)\theta u - \frac{u\dot{L}}{L} \tag{1}$$

[6] It is important to distinguish between the *individual* retirement probability which could well be decreasing in future as people are expected to remain in the labour force for a longer period of time and the *macroeconomic* retirement rate which is the share of older workers in the labour force. It is this latter rate which we analyse in this paper.

Since the growth rate of the labour force $\dot{L}/L = b - d$, the above can be written as

$$\dot{u} = (\lambda + \lambda_0 + b)(1 - u) - q(\theta)\theta u$$

from which follows, that the steady-state unemployment rate is

$$u = \frac{\lambda + \lambda_0 + b}{\lambda + \lambda_0 + b + q(\theta)\theta} \tag{2}$$

As can be seen from equation (2), only the labour-force entry but not the retirement rate influences steady-state unemployment rate. This result is due to the assumption that the retirement rate is the same both from unemployment as well as employment. Hence, if more people retire, this has an equal influence on both the unemployed and employed and therefore does not influence labour-market tightness.

Relaxing the assumption that the retirement rate out of employment and unemployment are the same and assuming instead that retirements out of unemployment d_u are higher than those whilst working d_e leads to:[7]

$$u = \frac{b + \lambda + d_u - d_e + \theta q(\theta) \pm \sqrt{4(b+\lambda)(d_e - d_u) + \big(b + \lambda + d_u - d_e + \theta q(\theta)\big)^2}}{2(d_u - d_e)} \tag{3}$$

Taking job-retirement and voluntary quits into account means that the standard job-creation condition from matching theory needs to be slightly modified as follows (compare equation (1.9) in Pissarides (2000: 12)):

$$p - w - \frac{(r + \lambda + \lambda_0 + d_e)pc}{q(\theta)} = 0 \tag{4}$$

where r is the interest rate, p denotes productivity and c are the costs of searching that firms incur when posting a vacancy. As can be seen from this equation, the birth rate has no direct influence on job-creation. The reason is that when a firm decides to post a vacancy, this decision depends on the expected duration of the productive match. This depends only on the retirement (from employment) and job-quitting rate but not on the birth rate. However, as the birth rate does affect the unemployment rate (3) and hence labour-market tightness, it has an indirect effect on job creation. *C.p.* a lower (higher) retirement rate from employment will increase (decrease) job-creation because lower (higher) productivity levels are required to make new jobs profitable since, on average, they last longer.

Wages are derived from the Nash bargaining solution that maximises the weighted product of the worker's and the firm's net return from the job match. The present-discounted value of being employed taking the quitting and retiring rates into account

[7] See Appendix A.1 for the derivation.

is given by

$$rW = w + (\lambda + \lambda_0)(U - W) - d_e W \tag{5}$$

and that of looking for a job is

$$rU = z + \frac{\beta}{1-\beta} pc\theta - d_u U \tag{6}$$

Using these equations and assuming that in equilibrium all profit opportunities are exploited, i.e. the current value of posting a vacancy is zero, leads to a modified wage equation given by:

$$w = \frac{z(1-\beta)(r+d_e) + p\beta(r + du + c\theta(r+d_e))}{r+du} \tag{7}$$

From the above, the steady-state is characterised by the Beveridge-Curve (3), the job-creation condition (4) and the wage equation (7). As the focus here is on the influence of a decreasing size of the labour-force population, we graphically analyse both a fall in the rate of people entering the labour force as well as a higher aggregate retirement rate from employment as a larger share of the population reach the retirement age at any given point in time.

Figure 1 shows how a lower labour-force entry rate influences wages and labour-market tightness. From above, it can be seen that this has no influence on the job-creation or wage condition. It only shifts the Beveridge-Curve to the left. As can be seen from panel (b) in Figure 1, a decrease in the birth rate reduces both equilibrium unemployment and the vacancy rate but does not affect labour-market tightness.

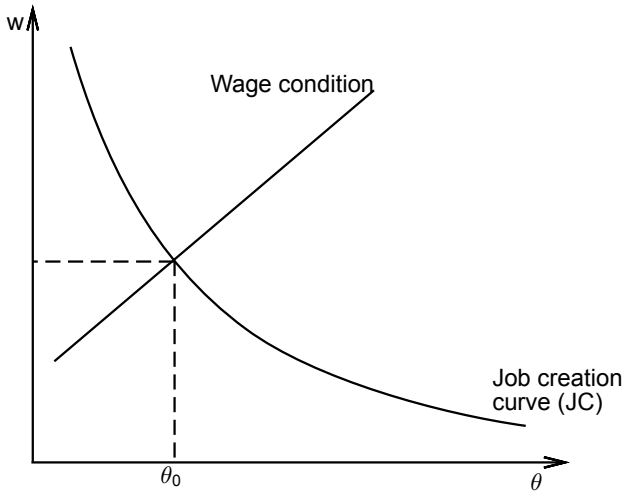
Figure 2 shows the effects of more people retiring from employment. As panel (a) shows, a higher retirement rate reduces labour supply and hence *c.p.* leads to higher wages. At the same time, an increase in the retirement rate shifts the job-creation condition to the left, i.e. decreases labour-market tightness θ as firms now offer fewer vacancies which counteracts the wage increase. From panel (b) it can be seen that the lower θ rotates the job-creation condition clockwise. An increase in the retirements (from employment) shifts the Beveridge Curve up because there are now fewer vacancies as these are now less profitable. The net result is higher unemployment. The effect on vacancies is not clear cut.[8]

Summarising the theoretical discussion, we find that in the context of a matching model, a lower labour-force entry rate due to declining birth rates leaves labour-market tightness unchanged (although the unemployment rate will be lower) whereas a higher retirement rate from employment reduces labour-market tightness (although the un-

[8] Augmenting this model by introducing endogenous job destruction does not alter the qualitative results. Compared to the basic model here this extension has the additional effect that if further lowers labour-market tightness as labour hoarding becomes less attractive for firms (i.e. jobs are destructed sooner) because the average job-duration goes down.

Figure 1: Decrease in the Birth Rate

(a) Wages and Labour-Market Tightness



(b) Vacancies and Unemployment

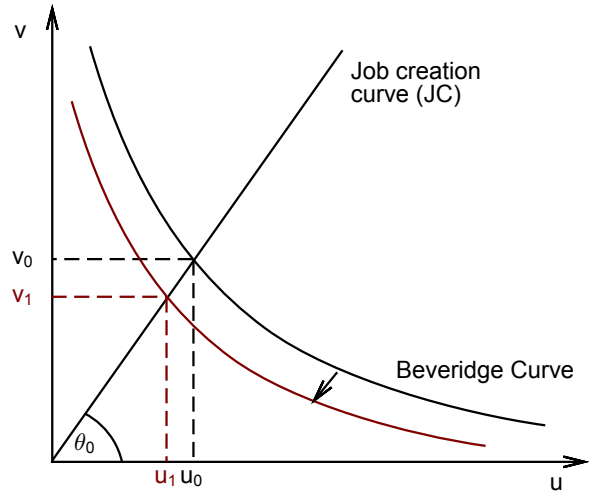
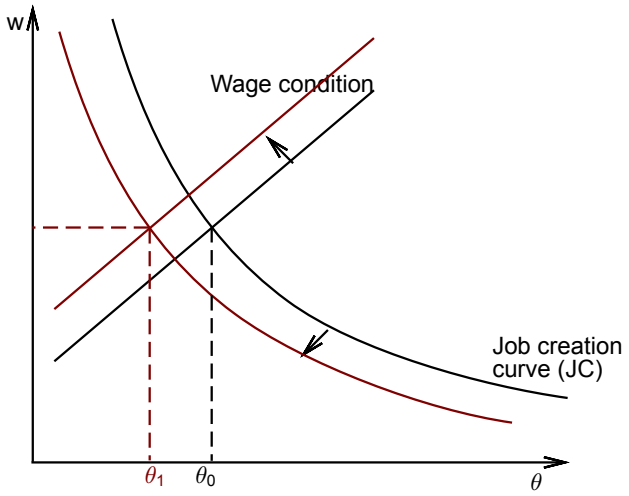
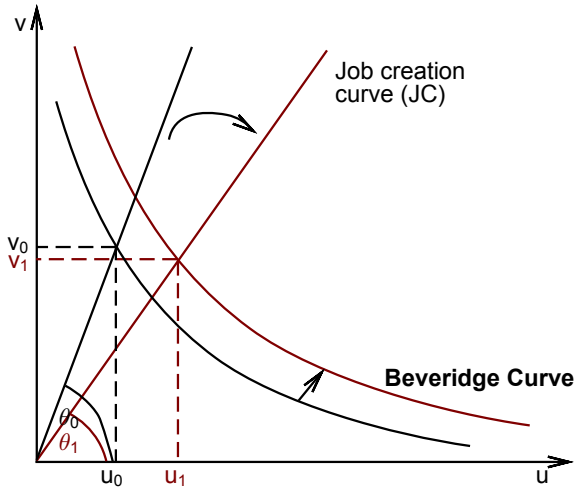


Figure 2: Increase in the Retirement Rate (from Employment)

(a) Wages and Labour-Market Tightness



(b) Vacancies and Unemployment



employment rate will be higher). Whereas the first result is at least partially in line with the popular “labour-shortage”-argument in that the unemployment rate decreases, the second finding clearly contradicts the statement that labour-market tightness will increase when more people leave the labour market. In our view this emphasises the fact that the “labour-shortage” and replacement-demand hypothesis are too simple in their argumentation as labour-market adjustments are not adequately accounted for.

3 Data and Empirical Results

Replacement Demand Across Occupational Groups

From the above we find no theoretical support for the argument that a lower birth and/or higher retirement rate leads to an increase in labour-market tightness. Instead, in the above model unemployment may actually increase due to the assumed demographic changes. In this section we empirically analyse using data from the Federal Employment Agency (FEA; *Bundesagentur für Arbeit*) whether in the past their was a significant relationship between the size of the cohorts leaving a certain market segment (here defined as an occupation on the 3-digit level) and the size of those entering in this market segment. If there is replacement demand and this is to be met by youngsters, we would expect many new youngsters to appear in those occupations where many old employees retired.

We use a large administrative dataset for Germany (the SIAB 1975–2010). This contains daily information on the labour-market status (i.e. employed (in a job subject to social-security contributions or a “mini-job”, unemployed or in an active labour-market programme) of 2 per cent of the labour force.[9] In order to not constrain the number of observations per occupation, we limit our analysis to West Germany as data for employment in East Germany only starts in 1992. We measure a persons labour-market status on June 30th of every year we have in the data.

We define a job-beginner as a person who is under 25 on their first observation in the data. As especially people obtaining academic degrees in Germany are often older than 25 when they leave university, we also test a second variant where job-beginners are allowed to be under 30 when we first observe them. If people are at least 30 years old upon first appearance in the data we assume that they are not job-beginners but perhaps previously worked as self-employed or abroad before starting a job subject to social security in Germany. If we observe a person who is at least 55 years old in year t but do not observe him or her in later years, then we assume that this person has retired from the labour force. If at time t we observe a person who is between 25 (30) and 54 years old in occupation x but either do not observe them in $t+1$ or observe them as being employed in a different occupation, we count them as an outflow from x. Table 1 gives a descriptive overview of how large the relative flows are.

[9] For a more thorough description of the dataset, see vom Berge/König/Seth (2013).

Table 1: Demographic In- and Outflows, Descriptive Statistics

Job-beginners	demo. inflows/ all inflows	demo. outflows/ all outflows	demo. turnover/ turnover	Range demo. inflow shares across years (excl. 1975)		Range demo. outflow shares across years (excl. 2009)	
				min	max	min	max
under 25	18.0%	10.9%	13.5%	13.5%	26.2%	8.8%	12.8%
under 30	22.5%		16.0%	17.0%	28.0%		

It can clearly be seen from Table 1 that demographically caused turnover (within an occupation) only represents between 13.5 and 17.0 % of total turnover. Clearly, other forms of turnover such as job-to-job changes (or in our case: switches between occupations), migration etc. must also play a major role.

Table 1 shows average values over all occupations. Obviously, there is a large amount of variance between occupations. For example, occupations for which a long time in education is needed tend to have fairly low rates of demographic inflows. Thus, doctors (0.5%) or master craftsmen (0.6%) have very low inflow rates, at least when only inflows for the people of age under 25 are counted. If inflows up to the age of 30 are counted, then the inflow rate for master craftsmen is the lowest (1.3%) whereas that of doctors measured at this age increased to 20.1%.

Occupations with relatively high inflow rates are hairdressers (46.0% if under 25 year olds are counted and 48,5% when the age limit is increased to 30) or bankers (35.0% and 40.0%, respectively).

Turning to outflows, these are lowest among chimney-sweepers (0.9%). Of particular interest is where the outflow rates are relatively high as in these occupations, at least according to the "replacement-demand" logic, these are the occupations where a labour shortage is most likely. We find the highest rates for road construction workers (37.1%) and stokers (35.6%). Obviously, both the professions do not make up a large proportion of the labour force. But it highlights the fact that looking at (future expected) retirement rates may not be helpful.

The starting point of our empirical analysis is the specification in Freeman (2006). He regresses the share of each occupational age group at time t on the share of this age group ten years before (to account for age-specific effects within an occupation) as well as the share of 55–64 year olds ten years before. The basic intuition is that – if replacement demand is important – then those who were 55–64 ten years ago should mostly be retired ten years later and have been "replaced" by the young age group. Therefore, the share of the young workers should be higher the higher the share of the older workers was ten years earlier.

As for these regressions we do not need individual labour-market data (which we need, when we focus on occupational change with a career), we use the official administrative data from FEA (1987–2011).[10] The results are shown in Table 2.[11]

As can be seen from the table, there is no significant relationship between a high (i.e. above average) share of 55–64 year olds ten years before and the share of younger workers in an occupation ten years later. Hence, at least according to this specification, we find no evidence of replacement demand occurring. Instead, there is a significantly positive relationship between the share of 55–64 year olds ten years before and the

[10] Due to a data revision, data with the same occupational classification scheme is not available after 2011.

[11] The coefficients and significance levels are shown in Table A.1 in the appendix.

Table 2: Freeman-Specification

Age group	55--64 year olds ten years earlier Share of employees
15--24	0
25--34	-
35--44	+
45--54	+

+: positive and significant at the 1 %-level;
-: negative and significant at the 1 %-level;
0: not significant at the 10 %-level

middle-aged groups. This could be an indicator that new workers are hired which previously worked in different occupations.

One of the main explanations of Freeman (2006) why he finds no evidence for replacement demand is that occupations with high shares of older workers ten years ago were occupations that were “dying out” and hence not attracting many more younger workers. For this reason, we ran the above specifications again once for occupations where total employment increased in our observation period and once for those where it decreased.

Focussing on the results for the 15–24 year olds (see Table A.1 for the full results), for growing occupations we now astonishingly find a significant negative relationship with regard to the shares. For occupations where the number of employees are decreasing between 1987 and 2011, the coefficient remains insignificant.

To further check for the dying out hypothesis of Freeman (2006), we also ran a specification regressing the growth rate of an occupation on the age structure 10 years before. The results show that the growth rate of a job is not significantly correlated with the size of the oldest age group in this occupation. This is also true when distinguishing between growing and shrinking segments.

The results so far are rather mixed. We therefore enhance the analysis of Freeman (2006) to additionally allow for year dummies and also include the age shares of all other age groups 10 years before (excluding those younger than 15 and older than 65 so that the shares to not add up to one). Hence, we allow for a relationship between the size of other cohorts and the respective cohort 10 years later; for example there might be an effect of the parents choice on that of their children. The own age group is again included to allow for aggregate demographic effects and all other effects on the relative cohort size across all occupations. We estimate this model to be able to control for occupation-specific effects on the age structure. This is probably an important extension since it allows occupations to possess a certain age structure. Thus, our estimated equation is the following:

$$ln(ageshare)_{i,t} = \alpha_0 + \sum_{age}(\alpha_{age} \cdot ln(ageshare)_{i,t-10}) + \alpha_{occup.} \cdot Doccup_i +$$

$$\alpha_{year} \cdot Dyear_t + \omega_{i,t}$$

where $\omega_{i,t}$ is the error term for occupation i and time t and assumed to match standard assumptions on the error term (i.i.d.). We now concentrate on the (log of the) shares as the dependent variable. Table 3 gives the sign of the coefficient only for the oldest age group 10 years before; the other results are in A.2 in the appendix.[12]

In addition, Table 3 also shows the results for several robustness checks: in the second row, we show results for full-time equivalents instead of a head count, which takes account of the fact that replacement demand also could be accommodated by increasing work time. In the third row, we weight the regression with the relative size of the occupation and in the next row we leave out an additional age group in order for the results not to be influenced by near multicollinearity.

Table 3: Extended Freeman-Model. Main Result and Robustness Checks for 15--24 year olds

55--64 year olds ten years earlier	
Specification	Coefficient
Basic	0
Full-time equivalents	0
Weighted regression	0
No. 35--44	+**
15--34	+***
Job-Growth-Rate	+*

+***: positive and significant at the 1 %-level;
+**: positive and significant at the 5 %-level;
+*: positive and significant at the 10 %-level;
0: not significant at the 10 %-level

In none of these specifications with the exception of the omitted 35–44 year olds do we find a significant relationship between the oldest age group 10 years before and the youngest age group 10 years after. Thus, the occupational choice at the beginning of a career does not seem to be driven by the variable that would proxy for replacement demand. However, it could be that labour shortage may be concentrated on the skilled and high-skilled. Especially for the high-skilled, defining the youngest age group to be at most 24 might be too restrictive as many are still studying at this age and only enter the labour market at a later age. For this reason we performed a regression where we define the youngest age group to be between 15 and under 35. As can be seen from the final row in Table 3 is that now we do find a positive relationship between the share of 55–64 year old ten years prior. As shown in Table A.2 – this also holds if we run separate regressions by different qualification levels.

What we also find, however, is that the next two age groups (25–34 and 35–44) are positively related with the retiring cohort ten years before (see Table A.2). At least the

[12] For all age groups (besides the youngest) there is obviously a strong positive relationship between the share at time t and the share of this age group when they were 10 years younger.

positive results for those aged 35–44 could be a hint that occupational changes may be important when there is a high replacement demand, i.e. large outflows (because the size of this age group ten years before is controlled in the regression as well). For this reason, in the following, we look at the influence of the age structure in an occupation on the probability of switching occupations more closely.

Occupational Changes

In this subsection, we perform two additional analysis in order to further explore whether occupational changes are an important mechanism in the context of replacement demand.

In a first step, we use the SIAB-data to differentiate job-inflows into a certain occupation into three components: first, job-beginners (defined as above; see Table 1); second, by people previously (i.e. one year earlier) working in different occupations or third, from people older than 25 (or 30) but not employed one year before starting the current job ("out of sample").[13]

In our base specification, we regress the share of job-beginners, occupational-changers and those coming from out-of-sample, respectively, on the share of outflows into retirement (i.e. the number of people retiring relative to the stock per occupation.)[14] We first perform a simple bivariate regression. Subsequently, as above, the same regression is run controlling for year and occupation fixed effects and finally as a weighted regression. The results are presented in Table 4.

Table 4: Regression Results for Inflow-Components

exog. variable: Share of Retirees			
Endog. Var. Inflow from …	Bivariate	Fixed Effects	Weighted Regr.
Job-beginners (u25)	-0.166***	-0.039**	-0.078**
Job-beginners (u30)	-0.260***	-0.061**	-0.078*
Occ. changers	0.328***	0.244*	0.417**
Non-employment	0.013	0.025	-0.096**
Total inflows	0.112	0.205**	0.268*
No. of observations: 11,152			
*** p<0.001, ** p<0.01, * p<0.05			

It can be seen from Table 4 that the effects do not differ greatly between job-beginners under 25 and those under 30. The share of both groups is negatively correlated with

[13] We call this last category out of sample although many of them are in fact unemployed and thus part of the sample. The reason is that a sizeable amount of individuals are not observed in the dataset between (un-)employment spells. This could be due to a number of reasons such as maternity leave, being in military service, a long illness, etc….

[14] Again, retiring is measured as being the last observation in the dataset at an age older than 55.

the share going into retirement, independent of whether the regression is run with or without fixed effects or is weighted (by the average employment share of the occupation). By far the quantitatively most important inflow component is from people who were previously employed in different occupations.[15]

The above regressions do not take interactions between the different inflows into account. It seems plausible though, that the inflow of, e.g., job-beginners also depends on how successful a firm was in recruiting workers via other channels. For this reason, we also perform a regression where the (share of) inflows from job-beginners, occupational-changers and non-employment are simultaneously estimated.[16] The results are shown in Table 5.

Table 5: Simultaneous Regression

	shares	Coeff.	Std. error
share of inflows by job-beginners (u25)	L1.inflows occup. change	-0.002**	0.001
	L1.inflows non-empl.	0.000	0.001
	L1.outflows retire	-0.025***	0.010
	L1.outflows occup. change	0.052***	0.005
	L1.outflows non-empl.	0.068***	0.006
share of inflows by occupational changers	L1.inflows job-beginners	-0.003	0.005
	L1.inflows non-empl.	0.005***	0.001
	L1.outflows retire	0.310***	0.019
	L1.outflows occup. change	0.275***	0.009
	L1.outflows non-empl.	0.151***	0.011
share of inflows from non-employment	L1.inflows job-beginners	-0.004	0.004
	L1.inflows occup. change	-0.001	0.001
	L1.outflows retire	0.038**	0.015
	L1.outflows occup. change	0.047***	0.008
	L1.outflows non-empl.	0.073***	0.009

No. of observations: 11,150

*** p<0.001, ** p<0.01, * p<0.05

From the first equation in Table 5 it can be seen that a higher share of new workers who were previously employed in a different occupation is negatively correlated with the share of job-beginners. Furthermore and contradictory to the “basic replacement demand” argument, an increase in the share of outflows into retirement is negatively related to the share of inflows by job-beginners. This is not the case if (shares of) outflows into different occupations or non-employment increase.[17]

[15] We also ran regressions on a two-digit occupation level. Again, it is the occupational changers with the largest effects.

[16] When using the equations simultaneously, we assume that the error terms of the three equations are uncorrelated and thus use the SURE framework.

[17] These results do not change for under 30 year old job-beginners.

The importance of occupational changers can also be seen from the second equation: a higher share of outflows into retirement is positively and significantly correlated with the (share of) inflows from other occupations. The same holds for the share of inflows from non-employment (see the third equation in Table 5).

The second additional analysis we perform to analyse the importance of occuaptional-changers is to define a dummy variable that takes on the value 1 every time an individual changes her or his occupation. To explain the likelihood of an occupational change, we run the following probit model, pool it over all observation years and maximise the likelihood of having observed our sample. Using the notation of Wooldridge (2002), we have:

$$Prob[OC_{ijt} = 1|X] = \Phi(X_{it}\beta + Y_{jt}\gamma + AgeS_{jt}\delta) \ ,$$

where $OC_{ijt} = 1$ if the individual i changes from occupation j to another occupation at time (year) t, X_{it} are control variables for the individual i, Y_{jt} are control variables for the occupation j and $AgeS_{jt}$ is the age structure in occupation j at time t. As far as the age structure of the occupation is concerned, we are particularly interested in the correlation between the share of older individuals (aged between 55 and 64) and the likelihood of an occupational change.[18] β and γ are the true effects of X and $AgeS$ on the probability of an occupational change. We assume that the error term of the latent variable (difference in the utility assigned to the potential new job minus the utility of remaining in the old job), determining the occupational change is i.i.d normally distributed with expectation zero and variance σ^2 and Φ is thus the c.d.f. of the normal distribution. X, Y comprises occupation dummies, the growth of the occupation over the last 10 years, the contemporaneous turnover rate in this occupation, the educational attainment of the individual, year dummies, gender, the age, the nationality, the age of the establishment, the relative wage of the individual relative to all others and relative to all others in the same occupation and professional status.

The astonishing result is that through almost all specifications[19], we find a significant positive correlation between the share of 55 to 64 years old in an occupation and the likelihood of changing the job. This is contrary to what we expected: from the perspective that individuals change jobs to meet replacement demand, people would change into occupations that have or had previously a high share of older individuals and remain in occupations with a high share of old individuals, given the growth rate of the job.[20]

[18] We alternatively use both the contemporaneous share of older individuals and, for consistency reasons, the 10 year lag and the cumulated shares over the last 10 years.

[19] Apart from the specification above, we also ran the regressions as logit models, linear panel models with fixed effects and panel probit models with random effects. We also ran yearly probit regressions. In a robustness check, we also constrained ourselves to ``voluntary'' occupational changes, defined as occupational changes with an intervening non-employment spell of a maximum of 31 days.

[20] One notable exception is a specification where we restrict the occupational change to persons that are always full-time employed throughout their career. The idea behind is that occupational changes that are linked to a change in the working time status might be linked to other events (e.g., family) and thus explained by different factors. In this specification, both for men and for women, the results for the share of older individuals is insignificant.

Table 6: Estimation Results: Probit-Regression

Variable	Coefficient	(Std. Err.)
growth_occupation_10yrs	0.005	(0.008)
share_55_64_L10	0.307	(0.098)
int_growth_share_L10	-0.142	(0.059)
female	-0.082	(0.003)
age	-0.003	(0.000)
foreigner	-0.043	(0.004)
relative_wage	-0.114	(0.006)
relative_wage_occupation	0.117	(0.006)
age_establishment	-0.005	(0.000)
size_establishment	0.000	(0.000)
Intercept	-1.312	(0.024)

Further covariates include dummies for the educational level, year, occupation and professional status.

4 Conclusion

In this paper, we analyse the replacement-demand argument which predicts a labour shortage based on the observation that many old individuals retire while few young ones enter the labour market both from a theoretical and an empirical point of view. In the theoretical part, we are not able to construct a model which gives rise to labour shortages and hence unsatisfied replacement demand: it is hard to think about economic mechanisms preventing wages from adjusting upwards and thus to prevent labour demand and supply from adjusting to demographic changes. This shows that theoretically this argument stands on a weak basis.

On the other hand, our empirical results are less clear cut. First, our results for Germany show that occupations which have a higher share of old workers are not those which are dying out as hypothesised by Freeman (2006) for the United States. Hence, we find no evidence that the reason why replacement demand may not be taking place is that there are simply only small total inflows into occupations with many older workers and hence large outflows. We further find that if the replacement demand is taking place, it is not satisfied from the youngest group (15–24), but more likely from the next two age groups (25–34 and 35–44). Thus, we believe occupational changes might play an important role in the adjustment process where the labour market adjusts to demographic changes. However, our results from microdata so far do not support this hypothesis either. The result that people move away from occupations that have a high share of older individuals, given both the growth rate and the turnover rate of the occupation, is stable. If these are the occupations which have particularly high replacement demand rates, then we would be expecting the exit rates from these occupations to be particularly low. Hence, we find no theoretical and mixed empirical support for the replacement-demand hypothesis.

Appendix

A.1 Derivation of the Unemployment Rate in Equation (3)

The change in the size of the labour force is now given by:

$$\dot{L} = bL - d_u uL - d_e(1-u)L$$
$$\frac{\dot{L}}{L} = b - d_u u - d_e(1-u)$$

Inserting this into (1) leads to:

$$\dot{u} = (\lambda + \lambda_0)(1-u) + b - d_u u - q(\theta)\theta u - u\big(b - d_u u - d_e(1-u)\big)$$

Solving this equation for u gives a steady-state unemployment rate $\dot{u} = 0$ denoted by:

$$u = \frac{b + \lambda + d_u - d_e + \theta q(\theta) \pm \sqrt{4(b+\lambda)(d_e - d_u) + \big(b + \lambda + d_u - d_e + \theta q(\theta)\big)^2}}{2(d_u - d_e)}$$

as noted in the main text in equation (3).

A.2 Full Results

Table A.1: Freeman-Specification

55--64 year olds ten years earlier	
All Occupations	
Age group	Share of employees
15--24	-0.024
25--34	-0.057***
35--44	0.131***
45--54	0.086***
Occupations with positive employment growth rates	
15--24	-0.067***
25--34	-0.122***
35--44	0.195***
45--54	0.210***
Occupations with negative employment growth rates	
15--24	0.037
25--34	-0.009
35--44	0.046***
45--54	0.018

*** p<0.001, ** p<0.01, * p<0.05

Table A.2: Extended Freeman-Specification

55–64 year olds ten years earlier	
Age group	Coefficient and Significance
Basic Specification	
15–24	0.019
25–34	0.148***
35–44	0.080***
45–54	-0.057***
Full-time equivalents	
15–24	0.014
25–34	0.127***
35–44	0.074***
45–54	-0.054***
Weighted regression	
15–24	-0.023
25–34	0.136***
35–44	0.089***
45–54	0.034**
15–34 year olds	
15–34	0.234***
35–44	0.120***
45–54	-0.127***
Low-Skilled	
15–34	0.286***
35–44	-0.023
45–54	-0.161***
Skilled	
15–34	0.153***
35–44	0.170***
45–54	-0.038***
High-Skilled	
15–34	0.064***
35–44	0.028**
45–54	0.009
No. 35–44 year olds	
15–24	0.120**
25–34	0.035
45–54	0.060*

Table A.2 continued on next page …

Table A.2 continued …

55–64 year olds ten years earlier	
Age group	Coefficient and Significance
Job-Growth-Rate	
15–24	0.073*
25–34	0.034
35–44	-0.047*
45–54	-0.098***

*** p<0.001, ** p<0.01, * p<0.05

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