Supply Shocks in the Market for Apprenticeships:

Evidence from a German High School Reform

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ABSTRACT

The G8 high school reform in Germany reduced minimum duration to obtain a high school diploma (*Abitur*) from 9 to 8 years. Implementation of the policy occurred statewide in specific years. Eight years later this resulted in graduation of two high school cohorts in one year. This paper studies how the additional inflow of high educated trainees changed the apprenticeship market. First, to conjecture possible effects of a supply shock in one input, a theoretical model is presented that is based on a CES technology with heterogeneous inputs. Implementation across states (*Länder*) was realized during different years. This allows applying a difference-in-differences estimation strategy to identify and estimate the size effects of one-time supply shock in market for high-educated apprentices. Training firms almost fully and immediately absorbed the additional supply of high school graduates in the apprenticeship market. In contrast with immigration studies no evidence is found for substitution effects between low and high educated apprentices. These outcomes can be explained by collectively bargained wages that are too sticky and too low for high educated apprentices. The German market for apprenticeships is characterized by insufficient flexibility.

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"The term "apprenticeship" means an arrangement that includes a paid-work component and an educational or instructional component, wherein an individual obtains workplace-relevant knowledge and skills." The White House, 2017[1]

1. Introduction

Economic benefits of the apprenticeship system are considered to be large. In a time when higher education is still getting more expensive a dual system that combines paid-work and instructive education is gaining popularity throughout. Last year alone in the UK and the US intensifying programs have been launched to foster dual training tracks for young school leavers.[1,2] Governments expect substantial returns to investment in the apprenticeship system, most importantly ameliorating young job seekers' employability, skills, and future careers.[3] Businesses as well report structural and increasing gains from contracting apprenticeships.[4]

A growing interest in the functioning of the market for apprenticeship training is evident among labor economists.[5] Under competition, firms continue to offer apprenticeship-training contracts until the marginal benefits equals the marginal costs of recruiting and training apprentices. A training contract can also be considered as a screening device. During the training period firms can obtain relevant information on the otherwise difficult to observe characteristics of potential workers. And firms may generate post-training benefits from retaining apprentices as skilled workers.[6]

How does a downward shock in high school duration influence the choice for apprenticeships? Despite widespread research on apprenticeship markets little is known about how this market reacts to shocks. This paper is meant to fill this void. It studies the impact of the implementation of the G8 school reform in Germany that decreased the minimum high-school duration by one year. The G8 reform caused a one-year

[1] https://www.whitehouse.gov/the-press-office/2017/06/15/presidential-executive-order-expanding-apprenticeships-america
[2] http://researchbriefings.files.parliament.uk/documents/SN03052/SN03052.pdf
[3] Wolter and Ryan (2011).
[4] In Switzerland the reported RoI from investment training is as large as 10 percent (Muehlemann *et al.* (2010)). Case-studies from the UK and the US also find similar substantial returns (Gambin *et al.* (2010), Corfe and Solomon (2014), Helper *et al.* (2016)).
[5] See Muehlemann (2016) for a review.
[6] Stevens (1994), Acemoglu and Pischke (1998, 1999), Blatter et al. (2016).

upward supply shock of high-educated school-leavers seeking for an on-the-job training contract. The paper evaluates the effects of the supply shock in a market for heterogeneous apprenticeships.

A theoretical model of the market for two types of apprenticeships is presented to predict possible outcomes of an upward shock in the supply of one of the inputs. Then an empirical analysis is performed on the implementation of the G8 reform that occurred in different states in different but one particular year. Eight years later this results in two high school cohorts graduating simultaneously in a specific state. In order to investigate the causal effect of the G8 policy implementation on the firms' demand for high education apprenticeships, the variation in supply shocks that occurs between different states in different years made it possible to apply a difference-in-difference estimation methodology.[7] A comparison of the theoretical predictions with the results of the econometric analysis will help to better understand some of the characteristics of the market of heterogeneous apprenticeships in Germany.

The next section provides a brief description of the German school and apprenticeship training system. The institutional setting of the apprenticeships market and the implementation of the G8 policy are also explained. Section 3 presents the theoretical model of the market for heterogeneous apprenticeships and the possible effects of a supply shock of one of the inputs. Section 4 presents the data. Section 5 explains the identification strategy and estimation methods. Section 6 presents the econometric results and examines changes in key indicators that have occurred since the implementation of the policy and the extent to which these changes can be attributed to the policy. Section 7 evaluates the outcomes from the perspective of market for apprenticeship training in Germany. Section 8 concludes.

[7] Previous studies have analyzed the relationship between school graduates and apprenticeship contracts (e.g. Baldi et al. (2014) and Maier and Walden (2014) for Germany, and Muehlemann et al. (2009) for Switzerland. However, demographic changes in the number of school graduates are typically small, and the number of training contracts adjusts smoothly over time.

2. Schooling and the apprenticeship system in Germany

After primary schooling, usually at the age of ten and based on school-grades, most school-leavers continue their education in a three-tiered system of secondary schools, either in *Hauptschule* (five years), *Realschule* (six years), or *Gymnasium* (nine years). The G8 reform reduced the minimum duration to obtain a Gymnasium diploma (*Abitur*) to eight years. Irrespective of the particular chosen school track, graduates can enroll in further vocational or general education, either school-based or as an apprentice. Only *Gymnasium* -- high-school -- graduates obtain direct access to the system of German university education.

The apprenticeship system

More than two-thirds of a cohort of school leavers graduates from schools of the two lower educational tracks, i.e. either *Hauptschule* or *Realschule*. A majority (around 65 per cent of a cohort) starts a vocational training program directly after leaving school. The dominant choice is of most individuals is to start an apprenticeship in the "dual system", which combines in-company training with part-time education in a vocational school. The age to start an apprenticeship is between sixteen and twenty years. The average entrance age has been increasing over the last two decades due to the fact that today more people choose to follow full-time education longer than a decade ago. In addition, high-school graduates may enter the dual apprenticeship system as well in stead of pursuing an academic education. In the years preceding the G8 school reform, approximately one out of five apprentices had obtained a university access qualification prior to the start of the apprenticeship (BIBB 2017).

[INSERT FIGURE 1 ABOUT HERE]

Figure 1 shows (in red) the number of high school applicants relative to the number of all applicants from *Hauptschule*, *Realschule* and *Gymnasium* between 2008 and 2016. This share increased from less than 15 percent in 2008 to 27 percent in 2016. This indicates that, relative to other school graduates, high-school graduates have become relatively more important in the apprenticeship market. The relative share of high

school graduates enrolling in apprenticeship is strongly associated with the overall increased share of high school enrollment in Germany. The annual number of high-school (*Gymnasium*) applicants for apprenticeships relative to the annual number of high-school graduates is marked in blue. This share is increasing over time as well, reaching the high level of 50 percent in 2014. Figure 1 underlines the fact that in the German apprenticeship system high-school graduates have gained importance through time. Consequently, how a more than gradual increase in the supply of high school graduates changes the market for apprenticeships is an important and relevant research question.

The economics of apprenticeship training in Germany follow the principles of regular labor markets. Neither individuals nor firms are legally obliged to participate in training. After graduation, students may formally apply for apprenticeships that are offered by firms. Following a screening process[8], the firm and the apprentice sign a training contract that defines wage payments and working conditions for the entire training period. Principally, wage payments are determined by collective agreements between employer associations and unions. Firms for which the collective agreements are not legally binding may deviate their wage setting rules by offering apprentice wages of no less than 20 percent *below* the minimum wage. Signing the contract implies that the firm commits to the provision of training according to occupation-specific and nationally binding training curriculums. At the end of the training period apprentices take an external exam to obtain their skilled-worker qualification (*Facharbeiter*). The system is characterized by a large coverage of occupations across all industries.

[INSERT TABLE 1 ABOUT HERE]

Table 1 displays the twenty most frequently chosen training occupations and their regular training duration in 2015. Clerical occupations, technical and metal producing occupations and traditional craft occupations are among the most popular apprenticeships. The median duration of an apprenticeship is three years. The

[8] See Wenzelmann et al. (2017) for a detailed analysis on the determinants of apprentice recruitment costs of firms.

twenty most frequent training occupations are jointly responsible for about half of all 1.34 million apprenticeship contracts in Germany.

The G8 high-school reform

The G8 reform results from the German commitment to the Bologna Process that aims at comparability of higher education qualifications across all European member states. In 2001 some federal states (*Länder*) started to implement the G8 school reform reducing the minimum duration of an *Abitur* by one year while keeping the curriculum content unaltered. The decision of when to implement the reform could be taken by each state separately. As a consequence thereof the implementation of the reform stretched over several years.

[INSERT FIGURE 2 ABOUT HERE]

Figure 2 presents a map of Germany that visualizes which state implemented the high-school reform in which year. It illustrates a one-time increase in the supply of high-school graduates on the apprenticeship market in those states that implemented the school reform in a particular year. Eight years after the implementation of the reform, between 2007 and 2013, in each particular state two rather than one cohort of graduates left the *Gymnasium*.

Supply shocks

Supply shocks in the labor market are usually studied in the academic literature on immigration. The theoretical models often assume competition, production functions that allow for substitutability between workers, and wages that are fixed in the short-run but flexible in the long run.[9] One relevant empirical study of supply shocks in the German labor market is by Pischke and Velling (1997). It finds little to no evidence of substitution effects due to immigration. A second, more recent study by Dustmann, Schönberg and Stuhler

[9] George J. Borjas (2016) Labor Economics. McGraw-Hill, 7th Edition, and the references therein.

(2017) considers heterogeneity between skilled and unskilled labor and finds a small decline in local wages and a substantial effect on unemployment due to immigration. This effect, however, is primarily due to firms reducing their input of new labor (diminishing the hiring rate). No evidence is found that firms increase the firing rate so as to make place for other - new - workers. Incumbent workers are shielded from supply shocks of foreign workers.

Other studies that address the effects of the German high school reform

As the duration of the high school curriculum was compressed from nine to eight years, it might be the case that the characteristics of high school graduates who applied for an apprenticeship position changed as a result of the reform. A number of recent studies address some particular issues, but the empirical outcomes provide an ambiguous picture. Dahmann (2017) finds that the high school reform did not have an adverse effect on the level of competencies of high school students at the time of graduation. Similarly, Meyer and Thomsen (2017) find that the high school reform did not have any negative effects on student dropout, performance, and motivation. Conversely, Büttner and Thomsen (2015) find a negative effect of the reform on grades in mathematics, while they report no adverse effects in German literature. They also find evidence that the reform decreased the final grade point average, and increased the probability of grade-repetition, although the economic significance of their results is rather moderate.[10]

Looking at personality traits, Dahmann and Anger (2014) analyze data from the German Socio-economic panel from 2002 to 2012 and find that the reform did not have a statistically significant effect on students' personality traits, including the locus of control, except for an increase in extraversion and a (marginally significant) increase in neuroticism.[11]

[10] Note that Büttner and Thomsen (2015) and Dahmann and Anger (2014) find negative effects on grades, while Dahmann (2017) investigates the scores on (standardized) competences, which may be a superior measure compared to relying on school grades.
[11] Note that the GSOEP relies on a very short version of the Big-Five inventory to measure personality traits, where each of the five personality traits is measured by three items only (Dahmann and Anger, 2014, p. 43).

In summary, the empirical findings suggest that -- if any -- the German high school reform had only a rather small effect on the cognitive and non-cognitive skills of high school graduates. From a firm's perspective this implies that the features of potential applicants for high education apprenticeship positions with a high school degree are largely comparable before and after the G8 reform.

3. A Theoretical Model with Two Types of Apprenticeships and Fixed Minimum Wages

In this section a simple static supply and demand framework for the market of apprenticeships is presented in order to investigate the possible effects of a one-time shock in high-educated apprenticeship supply. The model is meant to help interpret the empirical results of the effects of the G8 policy in the market for apprenticeships in Germany. Two types of apprenticeships compete on the market for apprenticeships. High education apprentices x_A require a minimum of 8 years of education (*A = Abitur = high school/gymnasium graduates*), and low education apprentices x_{NA}, require fewer years of education (*NA = Not Abitur = middle and lower track graduates/Hauptschule and Realschule*). Apprenticeship output y is produced according to a constant elasticity of substitution (CES) technology:

$$y = \left(\alpha x_A^{\rho} + (1-\alpha) x_{NA}^{\rho}\right)^{\frac{1}{\rho}}$$

where $0 < \alpha < 1$ is the constant share parameter and $-\infty < \rho \leq 1$ determines the degree of substitutability between x_A and x_{NA}. In this market the training firms are price takers. The marginal costs of apprenticeship contracting are fixed and differ between the two types, with $w_A \geq w_{NA} > 0$. Firms minimize their expected training costs subject to y

$$Minimize\ w_A x_A + w_{NA} x_{NA}$$

When -- short-run -- output $\bar{y}$ is constant then the two respective input demand functions are[12]

[12] See Appendix A1 for derivations.

$$x_A^*(w_A, w_{NA}, y) = \gamma \bar{y} \left(\frac{w_A}{\alpha}\right)^{\frac{1}{\rho-1}} \quad and \quad x_{NA}^*(w_A, w_{NA}, y) = \gamma \bar{y} \left(\frac{w_{NA}}{1-\alpha}\right)^{\frac{1}{\rho-1}}$$

with $\gamma = \left(\alpha \left(\frac{w_A}{\alpha}\right)^{\frac{\rho}{\rho-1}} + (1-\alpha)\left(\frac{w_{NA}}{1-\alpha}\right)^{\frac{\rho}{\rho-1}}\right)^{-\frac{1}{\rho}}$. The firm's cost function is

$$c(w_A, w_{NA}, y) = w_A x_A^*(w_A, w_{NA}, y) + w_{NA} x_{NA}^*(w_A, w_{NA}, y).$$

Marginal and average costs are the same and do not depend on the level of output

$$\frac{c(w_A, w_{NA}, y)}{y} = \frac{\partial c(w_A, w_{NA}, y)}{\partial y} = \gamma \left(w_A \left(\frac{w_A}{\alpha}\right)^{\frac{1}{\rho-1}} + w_{NA}\left(\frac{w_{NA}}{1-\alpha}\right)^{\frac{1}{\rho-1}}\right).$$

An upward shock in the supply of x_A when two inputs have unit elasticity of substitution

Consider the case most commonly used in (immigration) studies of supply shocks in the labor market first. This is when factor inputs x_A and x_{NA} have unit elasticity of substitution $(\rho = 0)$ and training output can be written as resulting from a Cobb-Douglas technology as follows:

$$y = x_A^{\alpha} x_{NA}^{(1-\alpha)}.$$

Under competition the input shares are independent of the relative costs w_A/w_{NA}. Marginal productivity for x_A and x_{NA} that result from competitive equilibrium inputs before the introduction of the G8 policy can be expressed, respectively, as

$$w_A = \alpha \left(\frac{x_A}{x_{NA}}\right)^{\alpha-1} \quad and \quad w_{NA} = (1-\alpha)\left(\frac{x_A}{x_{NA}}\right)^{\alpha}.$$

The implications of a positive supply shock in x_A on labor market conditions in the short run are set by the laws of supply and demand. When the supply curve for x_{NA} is upward-sloping and the demand curve is downward sloping then a positive shock in the supply of x_A will reduce the equilibrium input of x_{NA} (Borjas,

2003). The shift in supply of higher educated apprentices x_A lowers their productivity $\left(\frac{\partial w_A}{\partial x_A} < 0\right)$ and increases that of x_{NA} $\left(\frac{\partial w_{NA}}{\partial x_A} > 0\right)$.

Let x_i^t be the total number of apprenticeships, with $t \in \{0 ; 1\}$; $t = 0$ marks G9 (before the high school reform) and $t = 1$ marks G8 (after the high school reform); $i \in \{A ; NA\}$. The corresponding supply and demand curves are denoted as S_i^t and D_i^t, respectively. The short-run outcomes are summarized as follows

$$x_{NA}^1 < x_{NA}^0 \quad and \quad x_A^1 > x_A^0$$

$$w_{NA}^1 > w_{NA}^0 \quad and \quad w_A^1 < w_A^0$$

The share of high education apprenticeships $x_A/(x_A + x_{NA})$ increases due to two effects. The short-run demand increases for x_A and decreases for x_{NA}. Moreover, it may be the case that the productivity of G9 and the productivity of G8 apprentices are not the same. G8 productivity of may be lower than G9 because G8 has received one year less schooling. This in fact may imply a lower α, which changes the output elasticities of x_A and x_{NA} in this constant returns to scale production learning technology.

An upward shock in the supply of x_A when two inputs are complements

Next we consider the case that x_A and x_{NA} are complementary inputs producing y in fixed proportions. The short-run effect of a positive supply shock in x_A with x_{NA} remaining constant is comparable to the case of inelastic demand for x_A (Figure 3).

[INSERT FIGURE 3 ABOUT HERE]

In this particular case the short-run effects in the market for apprenticeships can be summarized as

$$x_{NA}^1 = x_{NA}^0 \quad and \quad x_A^1 = x_A^0$$

$$w_{NA}^1 = w_{NA}^0 \quad and \quad w_A^1 < w_A^0$$

The share of high education apprenticeships $x_A/(x_A + x_{NA})$ will remain unchanged. In the short run the productivity of low education apprenticeships w_{NA} is constant, while w_A decreases.

What if wages are sticky?

In Germany, wages of apprenticeship occupations are subject to collective bargaining agreements, and wage adjustments are restricted through institutional settings. The short-run analysis of the case for wage rigidity is particularly interesting because of the fact that the implementation of the G8-reform in the different states takes place in one-year periods at different times.

The marginal productivity of high-educated apprentices is likely to exceed that of low-educated apprentices. Moreover, because G9 apprentices are one year older at the time of graduation, it is possible that the marginal productivity of G8's is lower than of G9's. This would imply that

$$w_{NA} < w_A^1 \leq w_A^0$$

When wages are fixed, *ceteris paribus*, the demand for high education apprenticeships x_A will fall relative to the demand for low education apprenticeships x_{NA}. This is due to the fact that $w_A^0 = w_A^1$, so that w_A^1 is now "too high" while w_{NA} remains constant. Whether or not this effect will be observed depends on the fixed wage level for high-educated apprentices, w_A^*.

[INSERT FIGURE 4 ABOUT HERE]

Figure 4 illustrates the situation of institutionally restricted apprenticeship wages. Initial adjustment to the equilibrium level w_A^* does not occur since the demand for high education apprenticeships is too high and w_A^*

is too low. Wages are set at a level that is too low to clear the market. Given wage w_A^* the demand for high-educated apprentices exceeds the supply. The market condition is characterized by excess demand. When a supply shock occurs, the result is that the supply of high-educated apprentices will be absorbed entirely by the firms, such that

$$x_{NA}^1 = x_{NA}^0 \quad and \quad x_A^1 > x_A^0$$

4. Data and variable construction

The data source used for the empirical analysis is a register of all apprenticeships contracted per year. The contract information is collected by the regional chambers of commerce and then processed to the Federal Statistical Office. The delivery of the data is mandatory for the regional chambers, so that the register is a full sample of all apprenticeships in Germany, about 1.5 million apprenticeship contracts per year. Data include characteristics of the training (contract holder) and regional and occupation-specific information. This paper focuses on changes in the firms' demand for apprentices caused by the implementation of the school reform, and focuses on the number of new contracts that are signed in a respective year.

A panel data set has been constructed from the register that includes the number of new contracts in a given occupation, the regional state, and the contract year. A total of 321 occupations are recorded in the dual training system for all 16 federal states over a period from 2007 until 2013. This results in a total of 321 x 16 x 7 = 35,952 observations of which 9,366 triplets are apprenticeship contracts with people that have completed education less than *Hauptschule*. The paper's primary interest is in the development of high-education contracts. Hence these triplets are dropped and 26,586 observations remain.

An important variable to relate to is the average growth rate before, during and after the reform of school-graduates who graduated from the high track, *Gymnasium*, *and* thus having obtained the *Abitur*, from the medium track, *Realschule* with a minimum of six years of education to obtain a degree, or from the lower

track, *Hauptschule*, with only five years of education to obtain a degree. The numbers of school graduates is available at the federal state level over the 7-year observation period, and are obtained from the Federal Statistical Office, which publishes the data on a yearly basis (Destatis 2017).

[INSERT TABLE 2 ABOUT HERE]

Table 2 shows that the states that did not implemented the G8 school reform during the period 2007 through 2013 show an average positive growth rate of apprenticeship contracts of 1.7 percent per year. States that implemented the G8 reform were facing an average annual growth rate of 5.7 percent before the implementation of the policy. During the double cohort year the growth rate of high school apprenticeships increased by 18.4 percentage points from 0.975 to 1.159. Remarkably, after the G8 reform only high school graduates continued to see a 1.7 percent growth rate in apprenticeship contracts, while lower levels of education slightly reduced in volume. From these numbers alone it is difficult to tell the G8-story. The growth rates are based on aggregate numbers of apprenticeships per year per state. Moreover, the G8-years occurred in different years in the different G8-states, there is a positive trend in high school enrolment in most states, and there are important occupation-specific trends.

Apprenticeship wages

Wages of apprentices in Germany are bound to collective agreements and may vary between different training occupations. Regrettably, the register data on apprenticeship contracts does not include wages. Apprentice wage data by educational qualification are available from the German employment agency, but only in terms of median pay across all years of training and only for occupations or occupational fields with at least 1,000 contracted apprenticeships.[13] Given that in the smaller German states many occupations or even occupational fields comprise fewer than 1,000 apprentices it is impossible to obtain appropriate wage measures for heterogeneous apprenticeships that differ by educational attainment.

[13] Moreover, there are no wage data available for 2011 altogether, and a different occupational classification applied prior to 2011 compared to 2012 and later periods.

In order to provide at least some evidence as to whether the high school reform affected wages at the apprenticeship level, apprentice wages and wage development can be compared within occupational fields in three states: North Rhine-Westphalia (NRW), Bavaria, and Baden-Wuerttemberg. These are the three largest states in Germany. Together they employ more than half of all apprentices in Germany. In Bavaria, the double cohort of high school graduates entered in 2011, in Baden-Wuerttemberg in 2012, and in NRW in 2013. Apprentice wage data are only available from 2012 onwards. This implies that the wage development in NRW facing a supply shock in 2013 can be compared with post reform apprenticeship wages in Bavaria and Baden-Wuerttemberg.

[INSERT TABLE 3 ABOUT HERE]

Theory predicts that under competition a positive shock in supply of apprenticeship applicants would lead to a reduction in apprentice pay. Despite of the extra influx in NRW in 2013, median wages increased by 3.8 percent. The comparable median wage increases in the states that did not have a double cohort in 2013 are 5.3 percent in Bavaria and 4.0 percent in Baden-Wuerttemberg, respectively. The within-occupational field wage growth difference of apprentices with and without *Abitur* in NRW is 0.2%. It is however possible that the wage development along a certain trend line deviates between the states. A linear regression of wage growth within the seven occupational fields for apprentices with a high school degree shows that the wage growth in NRW was 0.9 percent-points lower compared to Bavaria and Baden-Wuerttemberg. The sample size is small and the coefficient is not statistically significant. This partial analysis for the three large states show that the upward apprentices supply due to the G8 school reform did indeed coincide with a lower median apprentice wage growth in NRW compared to the reference states that did not have such a supply shock in that year. The results suggest that the upward shock in supply of highly educated apprentices

searching for appropriate training contracts as a result of the high school reform did not result in downward wage adjustments, but it might have lowered the overall wage growth.[14]

The institutional setting of the German apprenticeship system is such that firms are restricted to adjust their wage offers downwards. Nothing however prevents these firms from upping their wage offers when they are facing a shortage in supply. In normal times, when there is no upward supply shock, the observed wages may be interpreted as equilibrium prices in a market that is transparent and competitive such that demand meets supply. In the one year that there is a significant increase of highly educated apprentices and given the institutionalized downward wage rigidity there is little firms can do other than hire as many apprentices as they find optimal for the apprenticeship wages set by collective agreements.

5. Identification of the effects of a supply shock in highly educated apprentices

A more comprehensive analysis involves a difference-in-difference econometric methodology to estimate changes in the realization of apprenticeship contracts that are due to the G8 policy. Let the log number of apprentices with a high school degree (*HS*) in an occupation *o* in state *s* in year *t* be written as a_{ost}^{HS}. To identify the effect of the G8 policy implemented in state s at year t (the dummy variable $G8_{st}$) on the number of apprentices with a high school degree we investigate first the model

$$a_{ost}^{HS} = \alpha_{os} + \lambda_t^{HS} + \theta^{HS} G8_{st} + \delta^{HS} ts_{t-1} + \gamma_o^{HS} t_o + \epsilon_{ost}^{HS} ,$$

where α_{os} controls for fixed effects in occupation *o* in a particular state *s* and accounts for the fact that baseline shares of apprentices with a high school degree vary by the training occupation and across states. Year dummies λ_t^{HS} control for year-specific effects other than the G8 policy. The trend variable t_o at the

[14] Westergaard-Nielsen and Rasmussen (1999) analyzed the effects of wage subsidies on the number of apprenticeship contracts in Denmark. They found that wage subsidies only affected the demand for apprentices in the low-wage industries (*eg*. restaurants).

occupation level *o* controls for occupation-specific developments through time.[15] A lagged measure of the log number of applicants who ended up in the transitory system (ts_{t-1}) is included to account for autocorrelation in the decision to contract apprentices independent of the G8 reform.

[INSERT TABLE 4 ABOUT HERE]

The results reported in Table 4 can be interpreted as follows. When controlled for occupation, state-fixed effects, state trends, and the number of unsuccessful applicants in the transitory system from previous years, the average double cohort graduate effect is 1.8 percent ($\hat{\theta}^{ALL}$). This overall increase was almost entirely due to the increase in high-education apprenticeship contracts increased by 7.4 percent $\left(\hat{\theta}^{HS}\right)$.

But the variable $G8_{st}$ simply denotes the change in the number of school leavers. In order to tell whether the relationship between school leavers and apprenticeship contracts is any different in a G8 year compared to other years the log number of high school graduates of a particular cohort of school leavers at the state-level in period *t*, g_t^{HS}, is added to the model. The difference-indifference specification of the model then is

$$a_{ost}^{HS} = \alpha_{os} + \lambda_t^{HS} + \beta_{st}^{HS} g_t^{HS} + \rho^{HS}(g_t^{HS} \times G8_{st}) + \gamma_o^{HS} t_o + \delta^{HS} ts_{t-1} + \varepsilon_{ost}^{HS},$$

The parameter β_{st}^{HS} measures the elasticity of the number of apprenticeship positions with respect to high school graduates. A one percent increase in the number of high school graduates increases the occupation-level number of contracts of apprentices with a high school degree by an estimated $\hat{\beta}_{st}^{HS}$ percent. The difference-in-difference parameter ρ^{HS} estimates the change in the share of apprentices with a high school degree within particular occupations as a result of the G8 reform. This parameter captures any differences in the substitution elasticity β_{st}^{HS} due to the G8 reform; ρ^{HS} measures the effect of the G8 school reform on high-education apprenticeship contracts.

[15] Jansen et al. (2017) estimate a model similar to this one.

Possible substitution effects of the increased supply of high-educated apprentices on the absorption by training firms of low-education apprenticeships can be estimated using similar regression models for all apprenticeships (a_{ost}^{ALL}), as well as for middle-track (a_{ost}^{MS} - *Realschule*) and low-track (a_{ost}^{LS} - *Hauptschule*) apprenticeships separately. In case of substitution the diff-in-diff parameters ρ^{MS} and ρ^{LS}, both identified by the G8 dummy variable, should be significantly negative.

Estimation results

Table 5 reports the outcomes of the regressions. The number of school graduates in previous years that ended up in the transitory system are found to be significantly related to the number of new apprenticeship contracts. This suggests that current school leavers searching for apprenticeship contracts not only compete with their peers from the current cohort but they also compete with applicants from previous years who were unsuccessful signing a contract immediately after graduation.

[INSERT TABLE 5 ABOUT HERE]

The elasticity of the all apprentices ($\hat{\beta}^{ALL}$) is 0.49 and significant. This implies that a 1 percent increase in the number of applicants increases the number of contracts by 0.49 percent. The estimate of the overall elasticity corresponds with Maier and Walden (2014), who report an elasticity of 0.60 based on an analysis at the state level between 1983 and 2003. Baldi et al. (2014) estimate an elasticity of 0.22 for the period 1999 to 2012.[16] The baseline elasticities for particular school types are, respectively, 0.35 for *Gymnasium* graduates ($\hat{\beta}^{HS}$), 0.47 for *Realschule* graduates ($\hat{\beta}^{MS}$), and practically nihil for *Hauptschule* graduates ($\hat{\beta}^{LS}$). When a large number of additional high school graduates cannot be absorbed by the apprenticeship market, the baseline elasticity of the number of apprenticeships with respect to graduates would be lower in times of a double cohort. In line with this argument, the coefficient of the interaction term of the G8 reform and

[16] For Switzerland, Muehlemann et al. (2009) report than an additional 10 school leavers increase the number of apprenticeships (measured at the state-level) by 2.7.

the number of graduates is indeed negative and statistically significant ($\hat{\rho}^{ALL} = -0.008$). The parameters $\hat{\rho}^{MS}$ and $\hat{\rho}^{LS}$ are small and insignificant. These results suggest that the contracting rates of applicants who graduated from the middle and lower tracks were not affected by the additional influx of high school graduates. The elasticity of high education apprenticeship contracts is significantly reduced as a result of the upward supply of high school graduates, that is $\hat{\rho}^{HS} = -0.011$; the magnitude of the reduction is rather small, such that the overall elasticity remains quite high ($0.352 - 0.011 = 0.341$). This result suggests that firms absorbed the additional high school graduates almost entirely, quite similarly as in regular years. The supply shock of highly educated apprenticeship applicants significantly increased the number of contracted high education apprenticeships without reducing the possibility to find apprenticeship contracts for graduates from the middle and lower tracks in the higher education system.

6. Can lessons be learned from these results?

When an upward supply shock occurs the constraint of a collectively agreed wage level being set too low should be less binding because under competition the equilibrium wage is expected to go down. In Germany that is not what happened during the implementation of the G8 high school reform. What happened is that at the time the apprenticeship market was facing a large upward supply shock of highly educated applicants for apprenticeship contracts, at least in Northrhein Westphalia their contracted wage grew about one percent less than in two other large states that did not see such an upsurge in supply at the time. This reduction likely coincides with the institutional restriction that firms are not allowed to reduce their contract wage for apprentices more than 20 percent below the collectively agreed wage level.

Although the additional supply in highly educated apprentices occurred at different years in different states, the increase always resulted in a substantial increase in the number apprenticeship contracts for high school graduates (*Gymnasium*). These increases did not reduce the intake of high-educated apprentices with lesser

educational qualifications (*Realschule* and *Hauptschule*). The school reform had a positive effect on the level of high education apprenticeships without a significant substitution effect on low education apprenticeships.

Figure 4 illustrates best the situation of apprenticeships and their institutionally restricted wage setting rules in Germany. Adjustment to the equilibrium level w_A^* does not occur since the demand for high education apprenticeships is too high and the collectively set wage level w_A^* is too low. The wage is set at a level that is too low to clear the market. The results support the notion that the market for high education apprenticeships is characterized either by highly elastic demand or by excess demand.

Let's consider both possibilities separately. Highly elastic demand refers to the fact that only a very small change in the wage would lead to a very large change in demand. That does not seem to appropriately reflect the case for German apprentices. There is nothing that restricts firms to slightly adjust their wage contracts, even though wages for apprentices are agreed upon collectively.

Excess demand can occur in a market that is heavily regulated. In Germany, collectively bargained wages do not differentiate by the educational qualification of apprentices. To the extent that apprentices with a high school qualification are more productive compared to other apprentices, the apprenticeship market for high-educated apprentices is burdened with too low collectively agreed wages levels. Even though nothing seems to restrict firms to increase wages or offer different contracts for different types of apprenticeships, there is clearly an excess demand for highly educated apprenticeships. Maybe the regular supply is just too little to satiate the annual demand of firms for apprenticeship positions. In that case it seems that a realistic option to improve the functioning of the market for highly educated apprenticeships is to introduce collective agreements for different schooling levels or, maybe less realistically in the short run, to discontinue the collective wage setting rules for all and let potential apprenticeship candidates and their contracting firms negotiate an appropriate wage themselves as is done in other countries like Switzerland, the UK and the US.

7. Conclusions and discussion

Today chances of finding a job when having obtained a university degree are substantially lower than, say, a decade or two ago. This is one reason that explains why taking up apprenticeships have increased in popularity among high school graduates who gained direct excess to university education through heir diploma. This paper analyzed the working of the market for highly educated apprentices. More specifically, the effects on the number of apprentices contracted by firms of a recent school reform are studied. The G8 school reform in Germany led to a supply shock of highly educated school graduates in the apprenticeship training market. Our results show that firms increased their demand for apprentices with a high-school degree without reducing the demand for low-educated apprentices. The one-time increase in high-school graduates was fully absorbed by the demand for high-education apprenticeships by the training firms. The supply shock that resulted from the G8 policy did not have significant substitution effects with respect to with fewer years of higher education.

These findings support the notion that the market for high-educated apprenticeships is characterized by excess demand that this is due to the fact that the market is too regulated and that the collectively bargained wages are too low for high-educated apprentices. The market for highly educated apprenticeships in Germany is insufficiently flexible.

Important policy implications can be deducted from the results of this study. The number of apprenticeship contracts is strongly associated with the cohort size of school graduates and heterogeneous effects by school type are present. Firms react to changes in the supply of graduates from middle school and high school tracks, but do not have similar responses to changes in the supply of graduates from the lowest education track. The demand elasticity of highly educated apprenticeships in regular years is 0.35 and reduces only slightly with 0.01 when a large upward supply shock hits the apprenticeship market, that is obviously capable of absorbing the strong increase in the supply of high school graduates.

Even though wages are sticky in the short-run because collective wage negotiations take place only every couple of years, firms may find other ways to make wage arrangements in the (high-ability) apprenticeship

market more flexible. For example, it seems that more and more firms offer a combination of apprenticeships and university studies at the bachelor level. This “dual track” contract, demanding as it may be for the high-educated apprentice, implies that the apprentice works less often in the firm. This implicitly increases the hourly wage. Further, high-school graduates have the option of shortening the training period by 0.5 to 1 year before signing the training contract. Firms might use this instrument to attract high-school graduates. Then apprentices enter the 2nd year of training straight away and can receive a higher starting wage. We could argue that firms seem to be searching for alternative options to be more competitive in the market for high-educated apprentices. Unfortunately, little substantial data are available to investigate this. We leave that for future research.

Although we identified ex-post reform effects, the results presented in this paper are also relevant to predict the effects on the apprenticeship market of a reversal of the G8 reform. This is currently discussed in several German states, and already concluded in Bavaria and Lower Saxony. Given the current institutional constraints, increasing the duration of high school to nine years again will lead to a significant drop in apprenticeship contracts at the time when only few high school graduates will enter the labor market for apprentices. This may render the shortage of supply of highly educated apprentices for training firms even more stringent.

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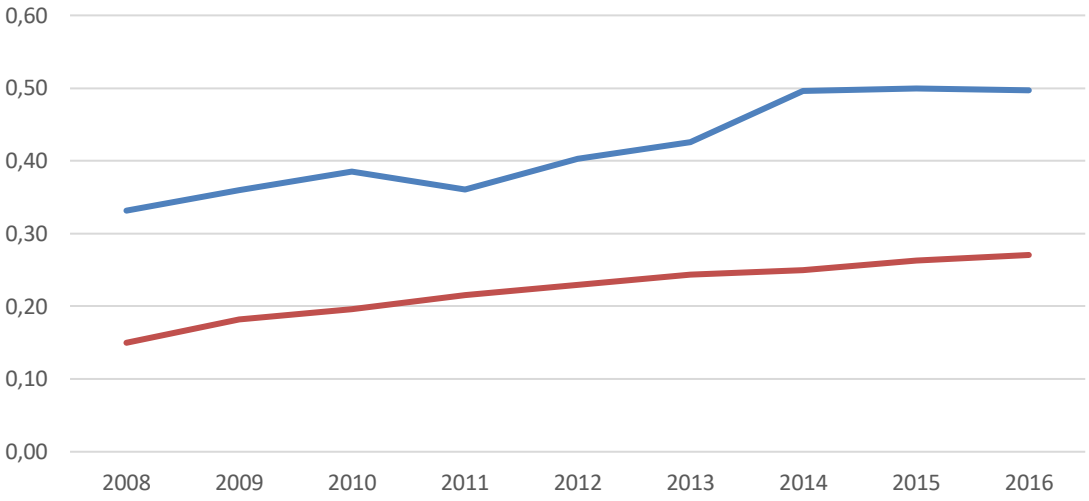
Figures

Figure 1:

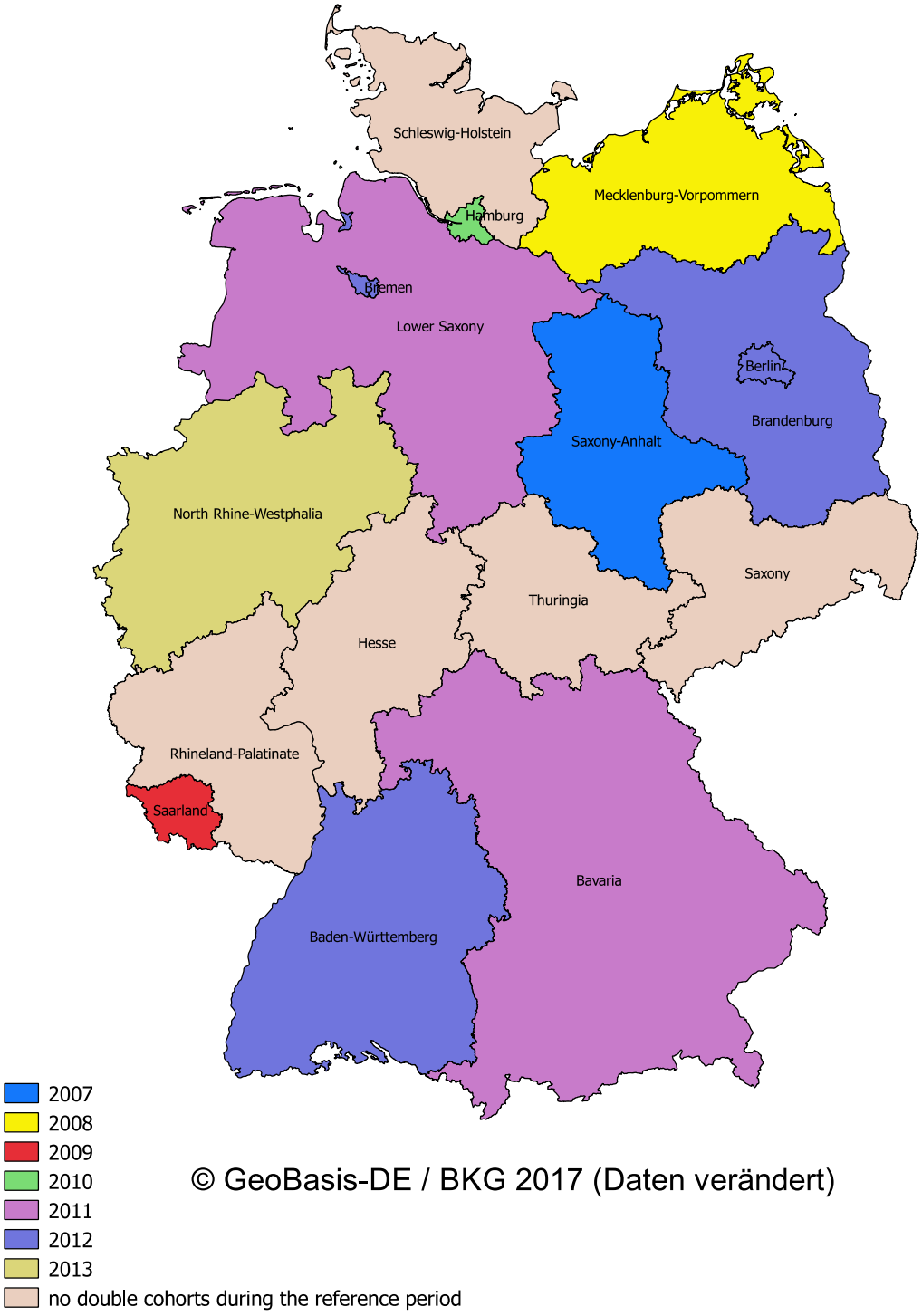
Applicant shares with high-school degree among a graduate cohort and among all applicants[1]



[1] Source: DESTATIS (2017) and BIBB Data Reports 2009-2017 (BIBB 2017). The annual number of high-school (*Gymnasium*) applicants for apprenticeships relative to the annual number of high-school graduates is marked in **blue**. The number of annual high school applicants relative to the annual number of all applicants from *Hauptschule*, *Realschule* and *Gymnasium* is marked in **red**.

Figure 2:

State and year of double cohort entering the apprenticeship market in Germany[1]



[1] Note that in Hesse, G8 was introduced stepwise, i.e. over two years. We therefore include Hesse in the group on non-G8 states. Including Hesse in the group of G8 states or leaving it out of the analysis does not significantly change the empirical results reported in this paper.

Figure 3:
Highly inelastic or complementary demand for high-educated apprentices

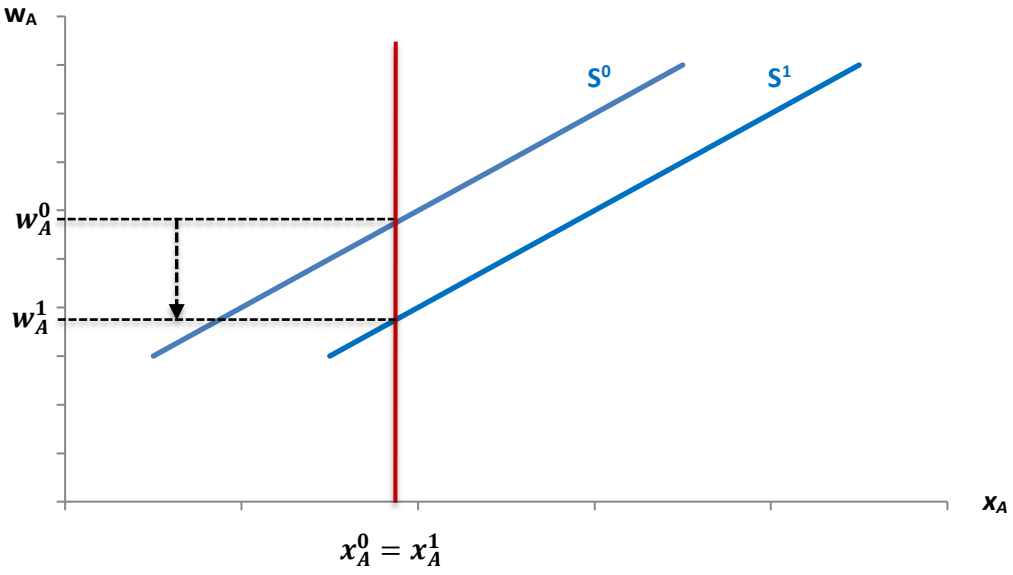


Figure 4:
Highly elastic or excess demand for high-educated apprentices

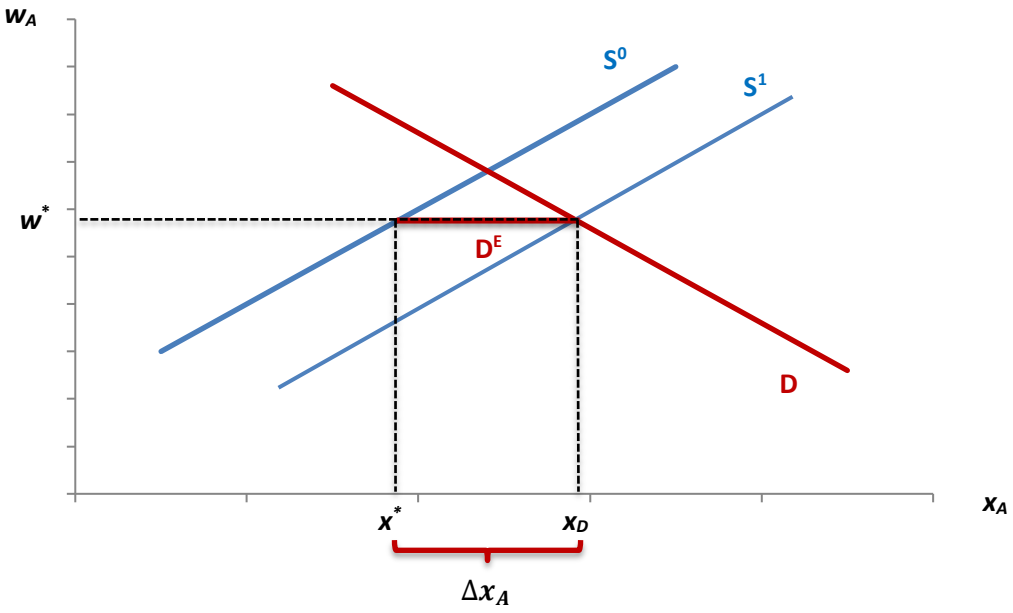
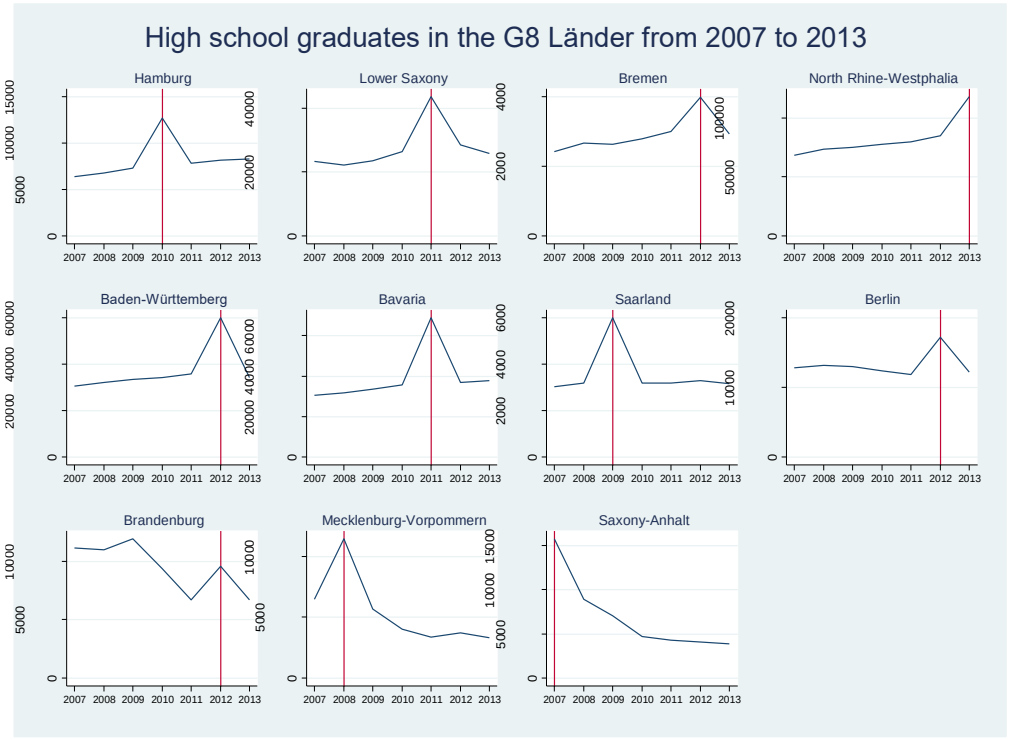
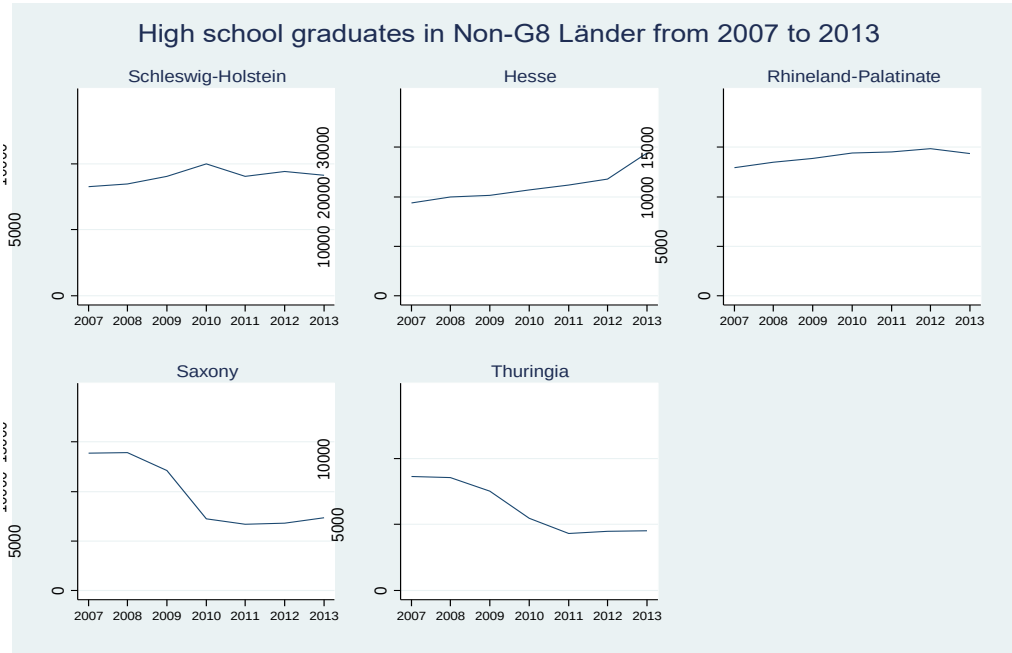


Figure 5:

Number of high-school graduates (*Abitur*) in federal states with and without school reform





Tables

Table 1:
Apprenticeship occupations in Germany in 2015

	Number of apprenticeship contracts	Duration according to training regulation
1. Office clerk	72,831	3.0
2. Automobile mechatronic	62,445	3.5
3. Clerk in retail	60,330	3.0
4. Clerk in industry	50,295	3.0
5. Industrial mechanic	46,428	3.5
6. Sales clerk	42,882	2.0
7. Clerk in trades	38,307	3.0
8. Electrician	35,430	3.5
9. Bank clerk	32,670	3.0
10. Plant mechanic for sanitary engineering	31,986	3.5
11. IT specialist	28,725	3.0
12. Mechatronics fitter	26,364	3.5
13. Logistics specialist	24,594	3.0
14. Electrician for industrial engineering	21,411	3.5
15. Milling machine operator	20,949	3.5
16. Cook	19,935	3.0
17. Metalworker	17,502	3.5
18. Carpenter	17,154	3.0
19. Painter and varnisher	14,799	3.0
20. Tool mechanic	11,898	3.5
Apprentices in all 20 occupations	676,935	
All apprentices (all occupations)	1,337,004	

Source: Statistisches Bundesamt, Fachserie 11, Reihe 3, 2015

TABLE 2:[1]

Average growth rates of apprenticeship contracts

	G9 States	G8 States		
	2007 - 2013	Before G8	Year of G8	After G8
Average growth[2]:				*- excl. G8 year -*
ALL	0.952	0.973	0.986	0.935
HS (= *Gymnasium*)	0.998	1.010	1.100	0.950
MS (= *Realschule*)	0.956	0.974	0.965	0.937
LS (= *Hauptschule*)	0.938	0.967	0.958	0.921

[1] Standard deviations are reported between brackets. [2] The average annual growth rate of apprenticeship contracts per state.

Table 3:

Apprentice wage changes between 2012 and 2013 in three states

Occupational field	Δwage (in %, HS degree) NRW	Bavaria	Baden-Wuertt.	Δwage (in %, no HS degree) NRW	Bavaria	Baden-Wuertt.
Trade	2.7	4.34	4.11	4.13	3.01	4.95
Administrative services	2.12	4.63	3.66	3.5	3.61	4.55
Manufacturing	2.51	6.02	2.81	4.17	4.14	2.39
Banking and insurance	4.38	4.9	3.85	2.66	3.98	3.38
Management	3.55	3.4	4.08	2.42	4.29	3.35
Health	5.62	5.94	4.47	5.98	5.56	4.87
Electrotechnics	5.62	7.62	5.26	5.06	4.47	4.6
Average	3.79	5.26	4.03	3.99	4.15	4.01

OLS Regression[1]

	Δwage (in %, HS degree)	Δwage (in %, no HS degree)
NRW	-0.864	-0.094
	(0.633)	(0.520)
Constant	4.650***	4.082***
	(0.337)	(0.232)
Observations	21	21
R^2	0.096	0.002

[1] Dep. variable: %-change in apprentice wage between 2012 and 2013 in 7 occupational fields. Reference group: Bavaria and Baden-Wuerttemberg. Standard errors in parentheses; *** $p < 0.01$.

Table 4:
Number of apprentices per occupation and state

	ALL	*HS degree*	*MS degree*	*LS degree*
G8	0.0185**	0.0737***	0.0124	0.0118
	(0.009)	(0.012)	(0.011)	(0.012)
$\ln(TS_{t-1})$	0.0683***	0.0544*	0.0641**	0.0510
	(0.023)	(0.032)	(0.028)	(0.034)
Observations	26586	19663	23924	20537
R^2	0.241	0.177	0.180	0.148

[1] Dependent variable is the log number of apprenticeship contracts in occupation and state (α_{ost}). HS = High school, MS = Middle track, LS= Lower track. The regressions also include annual fixed effects, occupational trends (t_o), the log number of applicants that ended up in the transitory system one period lagged (ts_{t-1}), and a constant. Standard errors are given within parentheses. Observations per school track can differ due to absence of apprenticeships in relevant occupations. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5:
Difference-in-difference estimates[1]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All AC	All $AC_{0.3<HS<0.7}$	AC^{HS}	$AC^{HS}_{0.3<HS<0.7}$	AC^{MS}	$AC^{MS}_{0.3<HS<0.7}$	AC^{LS}	$AC^{LS}_{0.3<HS<0.7}$
ln Grads_{all}	0.491***	0.352***						
	(0.0284)	(0.0516)						
G8 × ln Grads_{all}	-0.00805***	-0.00348**						
	(0.000988)	(0.00176)						
ln Grads_{HS}			0.393***	0.341***				
			(0.0223)	(0.0339)				
G8 × ln Grads_{HS}			-0.0113***	-0.00812***				
			(0.00161)	(0.00247)				
ln Grads_{MS}					0.468***	0.381***		
					(0.0302)	(0.0544)		
G8 × ln Grads_{MS}					-0.00108	0.000304		
					(0.00103)	(0.00182)		
ln Grads_{LS}							0.0624	-0.0657
							(0.0457)	(0.120)
G8 × ln Grads_{LS}							0.00104	0.00227
							(0.00120)	(0.00293)
ln Former grads in TS	0.0751***	0.0524*	0.102***	0.137***	0.160***	-0.0222	0.0957***	0.0977*
	(0.0169)	(0.0303)	(0.0231)	(0.0351)	(0.0192)	(0.0342)	(0.0207)	(0.0526)
Occupational trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-2.775***	-1.011**	-2.849***	-1.898***	-3.651***	-0.722	0.830*	1.234
	(0.253)	(0.460)	(0.219)	(0.333)	(0.278)	(0.505)	(0.444)	(1.182)
Observations	26586	7116	19663	6551	23924	6371	20537	4169
R^2	0.240	0.201	0.170	0.179	0.176	0.165	0.139	0.091

[1] Dependent variable is the log number of apprenticeship contracts in occupation and state (α_{ost}). HS = High school, MS = Middle track, LS= Lower track. The regressions also include annual fixed effects, occupational trends (t_o), the log number of school graduates (g_t), the log number of applicants that ended up in the transitory system one period lagged (ts_{t-1}), and a constant. Standard errors are given within parentheses. Observations per school track can differ due to absence of apprenticeships in relevant occupations.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix A1

Apprenticeship output y is produced according to a CES technology $y = \left(\alpha x_A^{\rho} + (1-\alpha)x_{NA}^{\rho}\right)^{\frac{1}{\rho}}$, where $0 < \alpha < 1$ is the constant share parameter and $-\infty < \rho \leq 1$ determines the degree of substitutability between x_A and x_{NA}. The marginal costs of apprentices are fixed and differ between the two types of apprenticeships, with $w_A \geq w_{NA} > 0$. In the short run output $\bar{y}$ is constant. Firms minimize their expected training costs $w_A x_A + w_{NA} x_{NA}$ subject to $\bar{y}$.

The Lagrangian function for this problem is

A1. $$\mathcal{L}(x_A, x_{NA}, \lambda | w_A, w_{NA}, \bar{y}) = w_A x_A + w_{NA} x_{NA} + \lambda\left(\bar{y} - \left(\alpha x_A^{\rho} + (1-\alpha)x_{NA}^{\rho}\right)^{\frac{1}{\rho}}\right).$$

The first-order conditions are $\mathcal{L}_A = \frac{\partial \mathcal{L}}{\partial x_A} = 0$, $\mathcal{L}_{NA} = \frac{\partial \mathcal{L}}{\partial x_{NA}} = 0$, and $\mathcal{L}_\lambda = \frac{\partial \mathcal{L}}{\partial \lambda} = 0$. The first two conditions show that at the point of equilibrium the isoquant curve is tangent to the isocost line

A2. $$\frac{w_A}{w_{NA}} = \frac{\alpha}{1-\alpha}\left(\frac{x_A}{x_{NA}}\right)^{\rho-1}.$$

The point of tangency determines the equilibrium inputs x_A^* and x_{NA}^* at output level $\bar{y}$. Rewrite A2 in terms x_A and x_{NA}, respectively. Substitution into $\mathcal{L}_\lambda$ will obtain the short-run demand functions for the two types of apprenticeships

A3i. $$x_A^*(w_A, w_{NA}, \bar{y}) = \frac{\bar{y}\left(\frac{w_A}{\alpha}\right)^{\frac{1}{\rho-1}}}{\left(\alpha\left(\frac{w_A}{\alpha}\right)^{\frac{\rho}{\rho-1}} + (1-\alpha)\left(\frac{w_{NA}}{1-\alpha}\right)^{\frac{\rho}{\rho-1}}\right)^{\frac{1}{\rho}}}, \text{ and}$$

A3ii. $$x_{NA}^*(w_A, w_{NA}, \bar{y}) = \frac{\bar{y}\left(\frac{w_{NA}}{1-\alpha}\right)^{\frac{1}{\rho-1}}}{\left(\alpha\left(\frac{w_A}{\alpha}\right)^{\frac{\rho}{\rho-1}} + (1-\alpha)\left(\frac{w_{NA}}{1-\alpha}\right)^{\frac{\rho}{\rho-1}}\right)^{\frac{1}{\rho}}}$$

The cost function is $c(w_A, w_{NA}, y) = w_A x_A^*(w_A, w_{NA}, y) + w_{NA} x_{NA}^*(w_A, w_{NA}, y)$.

Define $\gamma \equiv \left(\alpha\left(\frac{w_A}{\alpha}\right)^{\frac{\rho}{\rho-1}} + (1-\alpha)\left(\frac{w_{NA}}{1-\alpha}\right)^{\frac{\rho}{\rho-1}}\right)^{-\frac{1}{\rho}}$. Now it is straightforward to show that the marginal and average costs are the same and do not depend on the level of output:

$$\frac{c(w_A, w_{NA}, y)}{y} = \frac{\partial c(w_A, w_{NA}, y)}{\partial y} = \gamma\left(w_A\left(\frac{w_A}{\alpha}\right)^{\frac{1}{\rho-1}} + w_{NA}\left(\frac{w_{NA}}{1-\alpha}\right)^{\frac{1}{\rho-1}}\right).$$