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The Supply of New Engineers in Germany

Michael Neugart

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Abstract

We estimate a labor supply model with German data on engineering enrollments and starting salaries. In one model agents have backward looking expectations, in the other rational expectations on future wages. Only the model with backward looking expectations delivers significant coefficients with signs in accordance with out theoretical model. Lagged enrollments as right hand side variables improve the fit of our model. The latter suggests the need for a theory of dynamic labor supply. Supply effects through changing sizes of cohorts do not explain variations in enrollments. In addition, we find that welfare improvements through the provision of information on future wages are considerable.

Keywords: labor supply, engineers, enrollments, occupational choice, naï ve expectations, rational expectations

JEL-Classification: J22, J24

Zusammenfassung

Angebots- und Nachfragelücken für qualifizierte Arbeitskräfte sind in den letzten Jahrzehnten in Deutschland, wie auch in anderen Ländern Europas und Nordamerikas immer wieder aufgetreten. Zuletzt entflammte sich eine Diskussion um die Ausgabe von sogenannten ‚Green Cards', die den von der deutschen Industrie postulierten zusätzlichen Bedarf von mehreren zehntausend Fachkräften in der Informationstechnologie (IT) decken sollten. Ferner zeichnet sich jetzt schon ein Mangel an Ingenieuren für die nächsten Jahre ab. Nicht zuletzt, weil Unternehmen auf der Suche nach IT Kräften zunehmend auf benachbarte Fachgebiete wie die Elektrotechnik, den Maschinenbau und die Mathematik oder Physik ausweichen. Solche Engpässe beim Angebot an qualifizierten Arbeitskräften wie auch „Akademikerschwemmen" bergen erhebliche volkswirtschaftliche Kosten für beide Seiten des Arbeitsmarkts. Die Unternehmen finden nicht den gewünschten Umfang an qualifizierten Mitarbeitern, den sie zur Entwicklung, der Produktion und dem Verkauf ihrer Produkte benötigen. Gerade wenn es sich dabei um Unternehmen in Schlüsselindustrien, wie etwa der schnell wachsenden Informationstechnologie, handelt, kann dies zu erheblichen Wachstumseinbußen führen. Aber auch für die Arbeitsangebotsseite entstehen durch Angebots- und Nachfragelücken Kosten. Schulabgänger stehen vor der Entscheidung, in welche Ausbildung sie investieren sollen. Geht es um die Frage eines Hochschulstudiums, dann umfasst der Investitionszeitraum vier bis fünf Jahre und die Größenordnung beträgt in der Regel einige zehntausend Mark. Sind bei Studienabschluss die gewünschten Jobs nicht auf dem Markt bzw. die Gehälter niedriger als erwartet, amortisiert sich die Bildungsinvestition womöglich nicht. Hätte man nicht oder etwas anderes studiert, stünde man besser da. Ebenso gilt bei einem Nachfrageüberhang, etwa für Ingenieure, dass sich bei den gegeben Arbeitsmarktbedingungen mehr Schulabgänger für ein Ingenieurstudium entschieden hätten, weil sie sich damit eine bessere Einkommens- und Berufssituation hätten verschaffen können.

Die Einschreibungen an deutschen Universitäten und Fachhochschulen für Ingenieurstudiengänge schwankten im Zeitraum von 1975 bis 1998 erheblich. 1975

immatrikulierten sich lediglich 15.000 Ingenieurstudenten an den Universitäten, 1990 waren es mehr als 25.000 und 1998 weit unter 20.000. In demselben Zeitraum entschieden sich mehr Studenten für ein Ingenieurstudium an der Fachhochschule, doch die Schwankungen sind in etwa die gleichen.

In dem vorliegenden Artikel wird nun untersucht, ob diese extremen Zyklen durch Veränderungen in den Einstiegsgehälter der Graduierten relativ zu einem alternativen Einkommen erklärt werden können. Hierbei überprüfen wir zwei Varianten der Erwartungsbildung für die zu erzielenden Gehälter nach Studienabschluss. Zunächst gehen wir davon aus, dass die Schulabgänger glauben, dass sie bei Studienabschluss die Einstiegsgehälter erzielen werden, die derzeit auf dem Arbeitsmarkt gezahlt werden („naive Erwartungsbildung“). Alternativ überprüfen wir die „rationale Erwartungshypothese“, die besagt, dass die Schulabgänger für ihre Entscheidung über die Bildungsinvestition alle zur Verfügung stehenden Informationen, so auch die über die Zukunft, in ihr Kalkül aufnehmen. Nur die erste Variante der „naiven“ Erwartungsbildung führt zu statistisch signifikanten Ergebnissen. Damit werden Ergebnisse ähnlicher Untersuchungen für U.S. amerikanische, schwedische oder niederländische Daten bestätigt. Der Erklärungsgehalt unseres Ansatzes erhöht sich, wenn wir neben der Veränderung der Einkommen die um ein und zwei Jahre verzögerten Einschreibungen berücksichtigen. Dies deutet möglicherweise daraufhin, dass es „Moden“ oder „Herdenverhalten“ in der Studienwahl gibt. Ferner zeigen wir, dass demographische Faktoren keine Rolle spielen.

Wir berechnen „hypothetische“ Einschreibungen als die Anzahl der Studenten, die sich für ein Ingenieurstudium entschieden hätten, hätten sie die Arbeitsmarktsituation bei ihrem Studienabschluss gekannt. Es zeigen sich erhebliche Unterschiede zwischen „hypothetischen“ und tatsächlichen Einschreibungen. Daraus folgt, dass durch die Bereitstellung von Informationen über zu erwartende Arbeitsmarktentwicklungen Wohlfahrtsgewinne erzielt werden können. So könnten etwa regelmäßige Informationen und Prognosen zum Arbeitsmarkt und der Nachfrage nach Qualifikations- und Berufsgruppen durchgeführt werden, deren Ergebnisse der Öffentlichkeit zur Verfügung gestellt werden. Dies würde die

Entscheidung für eine Bildungsinvestition fördern, die letztendlich die erwartete Bildungsrendite abwirft, sowie Schwierigkeiten bei der Anwerbung qualifizierter Arbeitskräfte seitens der Unternehmen verhindern helfen.

Contents

1 Introduction

Shortages in the supply and demand for qualified labor have been occurring within the last decades. Thus, it is a well known phenomenon, even though the political debate on Green Cards may have mislead some of us to believe that it is something particularly new. A brief look at Figure 1 reveals quite large fluctuations in enrollments for the group of engineers, both to Fachhochschule and university. Enrollments of engineers to university started at 15.000 students in 1975, was more or less constant in the second half of the seventies, rose to 24.000 in 1983, fell afterwards and increased again with a peak of more than 27.000 enrollments in 1990. From there on enrollments decreased to 18.000 in 1997. Basically the same pattern can be observed for enrollments of Fachhochschule where only the size is larger. Only recently and briefly after the debate on how to deal with the shortage of qualified labor for the information technology sector, have fears been expressed that the supply of new engineers in Germany may not cover the demand within the next years (IWD, 10. August 2000, Nr. 23, p.8).

[insert Figure 1 here]

While we have been observing cycles in labor market tightness for many years there is still no agreement how to explain them. Clearly, a better understanding of the functioning of the labor market would help to prevent misallocation of labor and improve welfare on both sides of the market. Students would invest in an education that finally pays the expected returns after graduating, and firms would find labor supply that matches their demand in terms of quantity and qualification. Bottlenecks in factor supply that slow down growth could be circumvented. The aim of the paper is to test whether changes in relative wages can explain the dynamics in enrollments of German engineers that we have been observing for more than two decades.

The basic supply and demand framework suggests an upward sloping supply curve and a downward sloping demand curve. The scissors represent utility maximizing households and firms. On the side of the firms, the demand curve is downward sloping in the wage, if one assumes a fixed capital input for the short run and diminishing returns on labor. An increasing supply curve means that the substitution effect more than compensates the income effect of higher wages. The problem with the standard market model is, however, that is does not take into account the 'production lag' that comes with the supply of qualified labor. It takes time to become an engineer. This drives a wedge between the decision to enroll for an engineering degree and entering the labor market as an engineer. If students want to know whether it will finally pay to become an engineer they have to forecast the state of the labor market for the time they will graduate. This means to know the going wage of a few years ahead. The crucial assumption in terms of the standard model with a lag in the supply decision becomes how agents form these expectations.

The literature on cobweb models of the labor market assumes backward looking expectations, usually in the form of naive expectations. Students use today's relative wage to forecast what they are going to earn after graduating. Studies on the basis of cobweb models have been made for various segments of the labor market including the U.S. market for lawyers (Freeman 1975a), for physicists (Freeman 1975b), and engineers (Freeman 1976). More recently, Topel (1997) finds for Swedish and U.S. data that enrollments to college are driven by returns on education measured as today's ratio of college to high school wages. In an effort to explain historically low enrollment rates in the U.S. in the 1970's Card and Lemieux (2000) find, testing various hypothesis, that returns to education play a significant role for the slowdown of enrollments for men and women. A cobweb model with the relative rate of unemployment as an additional decision variable was estimated by Borghans et al. (1996) for Dutch data on choices of a two-year vocational training. In addition, they estimate a rational expectations model with the same data and find a better fit for the cobweb specification. Rational expectations models of occupational choices have been developed and estimated by Zarkin (1983 and 1985) and Siow (1984). When confronted with data on U.S. lawyers, the latter's supply model cannot be rejected, while the demand specification performs poorly. Zarkin tests his model with data for teachers and finds good fits for cobweb and rational expectations models but claims that in terms of forecasting behavior, his specification with rational expectations yields better results, because of the recursive structure of cobweb models.

We confront two models with our data set: one with backward looking expectations and a rational expectations model. Our data fits well to the specification with backward looking expectations. The coefficients on the wage variables are significant and show correct signs for the cobweb model but do not coincide with our prediction in the rational expectations model. Lagged enrollments as right hand side variables improve the fit considerably. This suggests that changes in relative wages cannot explain all the variation in enrollments. For the explanation of these adjustment processes, dynamic models of labor supply, maybe with “herd behavior” of agents might be a good starting point.

2 Models of Labor Supply

In its simplest version labor supply to the market is a function of the expected relative wage rate for the time when the education will be completed

$$S = S(w^e) .$$

The labor supply curve grounds on a utility maximizing household. If we assume that the substitution effect prevails over the income effect, the supply function is upward sloping ($S' > 0$). The crucial assumption with respect to labor supply of engineers refers to how we think about the expected relative wage w^e. As those students that enroll to a Fachhochschule or university will graduate in four or five years time, respectively, they have to predict the relative wage that will be paid then. Introducing time subscripts, we can write the labor supply at time *t* as a function of the expected wage *k* time periods ahead, with expectations formed at time *t* as

$$S_t = S({}_t w_{t+k}^e) .$$

Assuming backward looking expectations the simplest form to start with are naive expectations. In such a setting students just take the current starting salaries as a predictor for what they will earn once they will have completed their education. Then the expected relative wage for time *t+k* with expectations formed at time *t* writes as ${}_t w^e_{t+k} = w_t$. The supply of engineers, or more precisely, enrollments of engineers, becomes

$$S_t = S(w_t).$$

Latter is the baseline supply equation that we estimate in Section 4.1. However, there are infinitely many ways to formalize backward looking expectations. One could also model, for example, adaptive wage expectations with expected wages as a weighted average of actual and expected wages of the past, or a wage process were agents have a memory ranging back several time periods. In Section 4.1 we test one more alternative and lag relative wages for one period.

Afterwards we turn to a rational expectations model so that we can compare two extreme cases. With rational expectations we can write the expected wage for time *t+k*, with expectations formed at time *t* as

$${}_t w^e_{t+k} = E(w_{t+k}) + u_t$$

with

$$E(u_t) = 0 \text{ and } E(u_t^2) = s^2.$$

The rational expectations supply equation is estimated in Section 4.2. When we test the supply behavior in Section 4 we do this for engineers that enroll at a Fachhochschule or a university. The aim is to find out about what drives young men's and women's decision to become an engineer. From this, however, one cannot defer the supply of young engineers. This would require additional work on dropouts from school.

3 Data

The data comprises for a given year engineering students that enroll in the summer and winter term (ISAFSW for enrollments to Fachhochschule and ISAUSW for enrollments to university). It is taken from the records of the Statistisches Bundesamt that reports those series in Fachserie 11, Reihe 4.1, “Studenten an Hochschulen”. The data for monthly starting salaries for engineers stems from Verband Deutscher Ingenieure (VDI)[1] that does yearly surveys (IAGF stands for gross monthly starting salaries of Fachhochschule graduates and IAGU for gross monthly starting salaries of University graduates). In 1998 4.505 engineers replied to the questionnaires. The starting salary that is reported is the median of the monthly wages paid in the second and third quartile. The monthly salary comprises all payments received within a year, divided by 13. In the years 1988 and 1989, and between 1992 and 1998 no median is reported. As a proxy we take the average of the spread of the second and third quartile of monthly wages that is listed. As all other monthly salaries are medians this might cause a bias to our time series. However, we think that this problem is of minor importance as only the second and third quartiles, where large variations are less likely, are considered for the calculation of the median monthly wage. We can check for the years from 1974 to 1979 the difference that occurs from our calculation to the median approach. Latter is only small and does not systematically over- or understate the monthly wages of engineers. For the alternative salary (BWLA) we use the index of average gross weekly earnings of workers in the production sector. The Statistische Bundesamt reports that data in the Fachserie 16, Reihe 2.1, “Arbeiterverdienste im produzierenden Gewerbe”. We transformed all wage variables to indexes based on the year 1975. Figure 2 plots the indexes of starting salaries for Fachhochschule and university graduates relative to the index of wages paid to workers in the production sector. From there we can see, that in the second half of the 1970 starting salaries of academics dropped versus the wages paid to workers in the production sector. Relative wages of Fachhochschule graduates rose afterwards more than those of university graduates. For a whole decade starting salaries of engineers relative to the wages paid to workers remained fairly constant. This is in contrast to the rising wage inequality that has been observed in the U.S. during that time. Moreover, at the beginning of the nineties there is a sharp drop in relative wages for both Fachhochschule and university students. Only recently starting salaries for engineers relative to wages paid in the production sector have risen again. For the estimation all variables are in logarithms.

4 Estimation

4.1 Naive Expectations

The Market of Fachhochschule Engineers

Table 1 summarizes our results for enrollments to Fachhochschule on the grounds of a model with backward looking expectations. The regression equations (RQ) are numbered consecutively. In RQ 1 we regress enrollments on the starting salaries of Fachhochschule graduates, our alternative wage, and an intercept. The signs on the coefficients of the wage variables are both correct. The coefficient on the starting salaries is significant on a 10% level, the one on the alternative wage is not. The Durbin Watson statistic indicates serial correlation in the residuals and we can only explain half of the variation in the data. Both wage coefficients become highly significant if we lag the wage variable for one period (RQ 2). This raises the explained variation in the data by more than 15 percentage points. The residuals are still autocorrelated. Adding lagged enrollments to the right hand variable reduces but not eliminates the problem of serial correlation in the residuals (RQ 3 and RQ 4). For a lag structure of order four the Lagrange Multiplier (LM) test rejects the null

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[1] VDI-Report 27: Selbständige und Angestellte, Einkommensanalyse ,99. Hgg. von Heinz Evers und Holger

hypothesis of no serial. The coefficients on the lagged variables are highly significant. We think that this is an important results. It implies adjustment mechanisms for enrollments that changes in relative wages cannot explain. The significance of lagged enrollments as right hand side variables asks for an explanation beyond those that are already discussed in the literature. Our conjecture is that it might be worth looking for models with “herd behavior” where enrollment decisions of graduates from school can be independent from relative wage changes. With the RQ 4 we can explain 95% of the variation in the data. This is also illustrated in Figure 3.

[insert Table 1 here]

As the Statistische Bundesamt started reporting enrollments for engineering studies for the unified Germany only from 1993 onwards we generated a time series for male population aged 20 to under 21 years (B20). Until 1993 this time series consists of former West German population only, but reports population for East and West Germany from 1993 onwards. This allows us to check whether the supply effect of young men and women generated by the German reunification plays a significant role. It furthermore tests for effects on enrollments that arise through changing cohort sizes. The coefficient on the population variable in RQ 5 is insignificant. By comparing the coefficients of RQ 4 and 5 in Table 1 one can see that including the population variable hardly changes the results. Thus, we conclude that changing cohort sizes, including those caused by the reunification, do not explain variations in enrollments.

As logarithms were taken from all variables we can immediately see from the coefficient on IAGF(-1) that the short run labor supply elasticity is 0,63. Solving the difference equation in the usual manner by setting the lagged variables equal to the un-lagged variable, bringing them on the left hand side, and division of the equation

Hillmer, Düsseldorf 1999.

through the left hand side coefficient, one gets a long run labor supply elasticity of 1,7. Both elasticities fall into the range of other studies on labor supply.

[insert Figure 3 here]

The Market of University Engineers

The first RQ in Table 2 regresses university enrollments for engineers on starting salaries for university graduates in engineering (IAGU) and our alternative salary variable (BWLA). Both wage coefficients are significant on a five percent level. Again, the Durbin Watson test indicates serial correlation. If we take relative wages lagged for one period as explanatory wages we can improve on the significance even more. This also raises the explained variation in the data to 77%. Inserting lagged enrollments of one and two years consecutively as right hand variables increases the variance that we can explain with our regression to 0,89 (see also Figure 4). The LM test does not reject the null hypothesis of no serial correlation in the residuals for four lags. Including male population aged 20 to under 21 (B20) as an explanatory variable does not change our results (RQ 5).

[insert Table 2 here]

The short run labor supply elasticity, if we take the coefficients of the RQ 4, is 1,0. For the long run, the labor supply elasticity is 1,7.

[insert Figure 4 here]

Although both studies on enrollments deliver significant coefficients on our wage variables, we have to mention that our results are mainly driven by the data from 1991 onwards, from where on relative wages and enrollments dropped sharply.

Excluding the data for that time and rerunning the regressions still generates signs on the wage coefficients as predicted by theory. But those are insignificant. It follows that relative wage changes cannot explain the variation in enrollment data for engineers. Once, more one could interpret these findings on the background of a theory that takes ‘overreaction’ of market participants into account, in a way where small signals from the state of the labor market are amplified through “herd behavior”.

4.2 Rational expectations

For our estimates of the rational expectations model we follow McCallum (1976) and take actual wages *k* periods ahead as a proxy for rationally expected wages. This has become a common way to estimate rational expectations models (Nijman 1990) and the technical problems with respect to the estimation procedure are quite well understood. If we take actual wages as a proxy for rationally expected wages the variable will be correlated with the error term. It follows that the estimator will be biased. The correlation arises as per definition rational expectations are the best possible expectation about the future wage. Hence, the difference between our proxy variable, the wages that were actually paid then, and the rational expectations wage cannot be correlated with the rationally expected wage. Therefore, the error has to turn up in the residuals, making the latter correlated with the proxy variable. The second problem arises because the forecasting horizon (*k*) is larger than the sampling time of our data. This generates overlapping generations of students. If, for example *k=4,* there are at time *t,* if we abstract from the initialization and termination of the process, students who are at the beginning of their second, third and forth year of studies. Hence, unexpected news arriving within the last year of studies of the oldest generation will cause an error that is correlated with the error in the estimated supply function of the second oldest generation as they could not take this new set of information into account either. The same argument applies to the generations that are in their second and first year of studies. Thus, the error term will be autocorrelated. We deal with both problems by applying an instrumental variable technique while assuming no autocorrelation in the errors to correct for the correlation of our proxy with the error term. This gives us unbiased but inefficient estimators. In a second step, to improve on the efficiency, we assume a moving average process for the residuals and estimate the equation, again.

The Market of Fachhochschule Engineers

Table 3 presents the results of the estimation of the rational expectations model for Fachhochschule enrollments. The first row regresses the enrollments on the fitted starting salaries, alternative wages of four years ahead, and lagged dependent variables. The instrument for the starting salary was the lagged starting salary (IAGF(-1)) and for the alternative wage lagged wages by one and two periods (BWLA(-1), BWLA(-2)). Those are known at time *t* and cannot be correlated with the error term, therefore. As in the naive expectations model the coefficients on the lagged dependent variable are highly significant. The coefficient on the rationally expected starting salary (^IAGF(4)) has the correct sign and but is insignificant. The coefficient on the alternative wage variable (^BWLA(4)) has the wrong sign and is significant (RQ 1). The LM test indicates no serial correlation. In a second step, we model the residuals as a moving average process (MA(1)) and re-estimate the coefficients and standard deviations. The results of that are shown in the second row (RQ 2) of Table 3 (see also Figure 5). The coefficients on the wage variables are both insignificant, now.

[insert Table 3 here]

[insert Figure 5 here]

The Market of University Engineers

For the data on university enrollments we chose the same lag structure for the regression on the instrumental variables as before. The forecasting period for the rational agents is five years now, as the education at university takes in general at least one year longer. The regression on the fitted variables as shown in the first row of Table 4 yields significant coefficients for the lagged dependent variables, but insignificant coefficients and wrong signs for the wage variables. Modeling the error term as a moving average process (MA(1)) improves the efficiency of the fit but does not make the coefficients on the wage variables significant (see also Figure 6). The LM test indicates serial correlation, now.

[insert Table 4 here]

[insert Figure 6 here]

5 A measure for the need of policy intervention

Naive expectations of market participants and the lag structure in the adjustment process of Fachhochschule and university enrollments of engineering students imply that policy intervention may improve the allocation of educational choices. Were students graduating from Gymnasium or Fachoberschule informed about labor market prospects four or five years ahead, they may have chosen a different education. Based on the estimations of enrollment decisions of Fachhochschule and university entrants from Table 1 and Table 2 we can derive a hypothetical labor supply (c.f. Borghans et al. 1996). These are enrollments had students known the starting salary and the alternative wage when graduating from Fachhochschule or university by the time they started their education. For that purpose we generate a time series for enrollments by plugging into RQ 4 in Table 1 and Table 2, respectively, the starting salary and the alternative salary with a forward lag. The lags that we choose are four years for enrollments to Fachhochschule and five years for enrollments to university. This gives us the hypothetical short run labor supply: enrollments as they would have occurred had graduates from school known the going wages when they graduate from Fachhochschule or university. The difference between hypothetical and actual enrollments related to the latter gives the percentage of students that would have been better off had they forecast the wage correctly. Allowing for all adjustment processes to work themselves out we get a measure that relates to the long run supply response. This requires that we solve RQ 4 in Table 1 and Table 2, respectively, for the long run eliminating the lags. With what we get we generate a time series for the hypothetical long run supply. Comparing both measures, the short run and the long run error, gives us information on the importance of adjustment processes in enrollment decisions.

If we focus on the short run supply of Fachhochschule students (Figure 7), there would have been 1,5% more enrollments in 1977, had students known the wages from four years ahead. The misallocation declined in the following years and almost vanished in the mid eighties. From then on until 1992 less students would have chosen to become an engineer given they had known future wages. Comparing Figure 7 with Figure 8 indicates that there is quite a difference between long run and short run supply behavior. If we let the adjustment processes work themselves out we would have had almost 4,0% more enrollments in 1978. Thus, we can conclude that it is not only the lack of forward looking behavior that produces inefficient results, but also the slow response on the supply side of the market. Remember that the long run elasticity that we derived from Table 1 was almost three times as large as the short run labor supply elasticity.

[insert Figure 7 here]

[insert Figure 8 here]

In Figure 9 and Figure 10 we replicate the same exercise for university enrollments of engineers. The calculation of the hypothetical short run labor supply is based on RQ 4 of Table 2. We solve the same equation for the long run labor supply by eliminating the lags. As university studies take longer than those at Fachhochschule starting salaries and alternative wages are taken from five years ahead. Again, a larger part of students would have chosen to enroll as an engineering student than actually did, had they known the wages for the years between 1978 and 1986. From there onwards less students would have enrolled for engineering courses would they have had the correct information. Allowing for the long run response (Figure 10) more than triples the percentage of students that would have chosen to become an engineer within the first decade or our sample. From there on the more students would have enrolled for engineering courses instead of less if we compare the long run with the short run perspective.

We are aware that the suggested procedure is a crude measure of allocation on the labor market. It is, for example, sensitive on whether we compare actual to hypothetical enrollments in terms of logs or not. If we had taken the exponentials of the logged time series variables, errors in the constant term may have changed the result strongly. Especially in the long run case where the intercept is divided by a number smaller than one to eliminate lags this could have amplified errors in the coefficients that blur our indicator. But still we think that it can give us quite a good feeling of the extent of welfare losses that coincide with adjustment lags in enrollments and backward looking expectations of graduates from school. Would there have been more accurate information on the state of the labor market by the time the studies will be completed, different decisions would have been taken by quite a range of students. All those students would have been better off. We cannot give an explanation why graduates from school do obviously not collect sufficient information about the future, given that this would improve their position. However, as pointed out earlier, we suspect that a model with heterogeneous agents and imitating behavior may give an appropriate framework to study these adjustment processes.

[insert Figure 9 here]

[insert Figure 10 here]

6 Implications for Labor Market Policy and Theory

We tested two labor supply specifications with data on engineering enrollments and starting salaries. The ratioal expectations model does not yield proper results. The model with backward looking agents delivers significant coefficients on the wage variables with signs as predicted by theory. We can improve the accuracy of our model if we choose relative wages lagged by one period instead of current wages. This indicates that it takes time for the wage information to be processed until it serves as a decision variable for graduates from school. To get good fits in terms of explained variation in the data of more than 90% we have to depart from the static supply model and incorporate lagged enrollments as right hand side variables. This suggests complex adjustment processes that lack a proper theoretical justification. We believe that a good starting point to explain these dynamics could be a labor supply theory with "herd behavior" where enrollments are driven by imitation of the behavior of others and not changes in relative wages.

On the basis of a labor supply model with naive expectations we get enrollments based on the actual labor market conditions that are different from the figures with enrollments had graduates from school had the information about the labor market conditions when they complete their education. The hypothetical enrollment rates calculated backwards from the future states differ from actual enrollments. This suggest the need for policy intervention to assure efficient allocation on the labor market by providing information on labor market prospects to students.

This could be achieved by installing agencies that do professional forecasts and deliver the results to employment offices or make them public in general. In case there was no market failure such an "information agency" could be private. If graduates from school do better making decisions with the help of professional forecasts they will be willing to pay a price for that. One would expect that the information agency will ask for a price that equals the gain for students from choosing the education that gives them a higher return over the alternative. However, one may suspect that once the information is sold to a single person, others will participate by simply imitating the decision, saving the costs of collecting information on their own. It may happen that by free-riding the market for a private “information agency” becomes to small to cover setup costs and no such service will be offered. In that case, on would have to think about a public provider of labor market forecasts. Such a policy is supported by the costs of misallocation that seem to be quite high.

Welfare losses, as we defined them in our preceding chapter are mainly driven by a lack of information on the “correct” future wages. If there was a futures market for labor contracts, as there are for financial or agricultural products, predicting wages or labor market conditions in general would be less difficult. Given that such a futures market for labor contracts would reflect the information all agents have about the future, it would serve the “right“ incentive to invest into a specific education. No market adjustments would occur as driven by backward looking expectations. The speed of (re-)allocation would rise. Such a futures market for labor contracts could be handled similar to those games where people can bet for a specific result in governmental elections. What makes such an arrangement difficult here, is to find the criteria to bet against. It would have to be i.e. a wage rate paid in a specific segment of the labor market, the vacancy rate or the unemployment rate at some time in the future. Obviously, this is a difficult task, given that there exist numerous definitions for those rates. But it might be worthwhile to think about such arrangements.

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Tables

Table 1: Regression coefficients for engineers entering Fachhochschule, backward looking expectations model

No.	C	IAGF	BWLA	IAGF(-1)	BWLA(-1)	ISAFSW(-1)	ISAFSW(-2)	B20	R^2	DW	LM (4)
1	7,47	1,00	-0,45	-	-	-	-	-	0,51	0,43	-
	(0,61)	(0,51)	(0,49)								
2	7,29	-	-	1,72	-1,13	-	-	-	0,67	0,68	-
	(0,53)			(0,41)	(0,40)						
3	2,05	-	-	0,94	-0,81	0,73	-	-	0,91	-	0,02
	(0,80)			(0,25)	(0,22)	(0,11)					
4	2,63	-	-	0,63	-0,40	1,29	-0,66	-	0,95	-	0,01
	(0,62)			(0,20)	(0,19)	(0,15)	(0,16)				
5	2,65	-	-	0,63	-0,40	1,29	-0,66	-0,00	0,95	-	-
	(2,41)			(0,23)	(0,23)	(0,16)	(0,17)	(0,16)			

Table 2: Regression coefficients for engineers entering university, backward looking expectations model

No.	C	IAGU	BWLA	IAGU(-1)	BWLA(-1)	ISAUSW(-1)	ISAUSW(-2)	B20	R^2	DW	LM(4)
1	6,69	1,46	-0,80	-	-	-	-	-	0,59	0,66	-
	(0,59)	(0,38)	(0,32)								
2	6,48	-	-	1,88	-1,18	-	-	-	0,77	1,13	-
	(0,45)			(0,28)	(0,23)						
3	3,27	-	-	1,11	-0,77	0,51	-	-	0,86	-	0,08
	(0,96)			(0,31)	(0,22)	(0,14)					
4	3,84	-	-	1,00	-0,63	0,85	-0,42	-	0,89	-	0,07
	(0,89)			(0,28)	(0,21)	(0,20)	(0,18)				
5	6,32	-	-	1,12	-0,74	0,86	-0,43	-0,17	0,90	-	-
	(3,0)			(0,32)	(0,25)	(0,20)	(0,18)	(0,20)			

Table 3: Regression coefficients for engineers entering Fachhochschule, rational expectations model

No.	C	^IAGF(4)	^BWLA(4)	ISAFSW(-1)	ISAFSW(-2)	MA(1)	R^2	LM(4)
1	3,03	0,07	0,52	1,30	-0,90	-	0,95	0,65
	(0,81)	(0,27)	(0,24)	(0,20)	(0,20)			
2	3,52	-0,10	0,68	1,15	-0,78	0,59	0,96	0,94
	(1,16)	(0,31)	(0,32)	(0,28)	(0,27)	(0,28)		

Table 4: Regression coefficients for engineers entering university, rational expectations model

No.	C	^IAGU(5)	^BWLA(5)	ISAUSW(-1)	ISAUSW(-2)	MA(1)	R^2	LM(4)
1	4,09	-0,00	0,63	0,92	-0,66	-	0,87	0,34
	(1,46)	(0,35)	(0,32)	(0,26)	(0,25)			
2	3,19	0,26	0,47	1,27	-0,97	-0,93	0,93	0,01
	(0,75)	(0,17)	(0,14)	(0,18)	(0,18)	(0,08)		

Figures

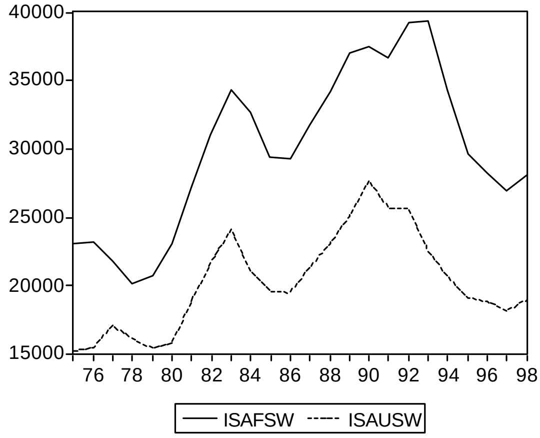

Figure 1: Enrollments of engineering students for Fachhochschule (upper curve) and university (lower curve).

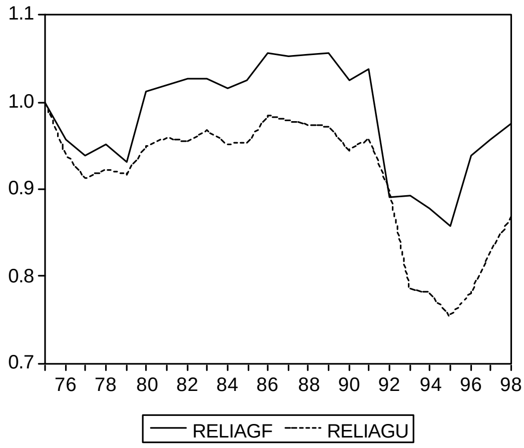

Figure 2: Index of starting salaries for Fachhochschule and university graduates (dotted line) relative to the index of wages paid to workers in the production sector, 1975=100.

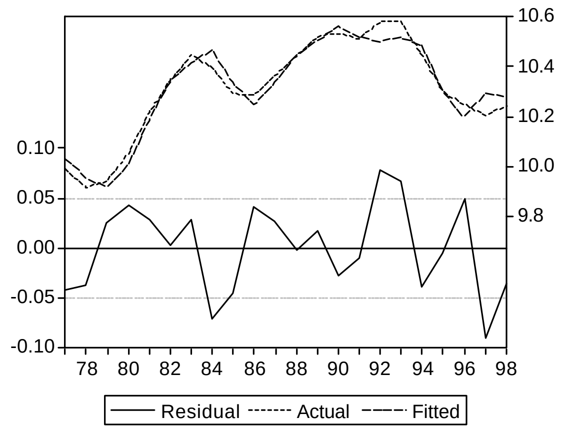

Figure 3: Actual and fitted values, and residuals for Fachhochschule enrollments of engineers, backward looking expectations model, wages lagged on period.

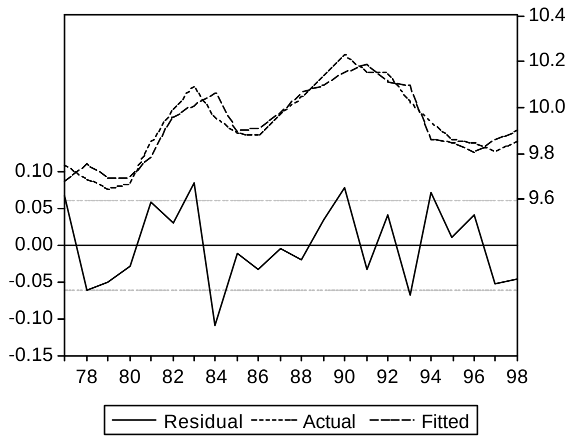

Figure 4: Actual and fitted values, and residuals for university enrollments of engineers, backward looking expectations model, wages lagged on period.

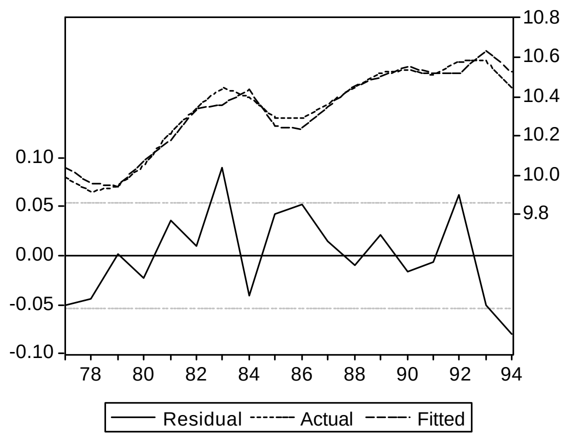

Figure 5: Actual and fitted values, and residuals for Fachhochschule enrollments of engineers, rational expectations model.

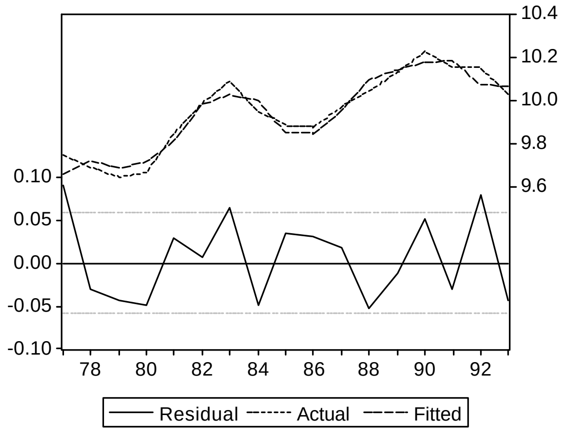

Figure 6: Actual and fitted values, and residuals for university enrollments of engineers, rational expectations model.

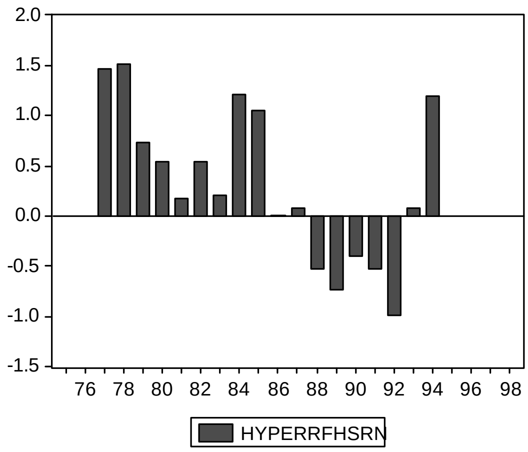

Figure 7: Errors in labor supply decisions of Fachhochschule students – with comparison to short run labor supply, [%].

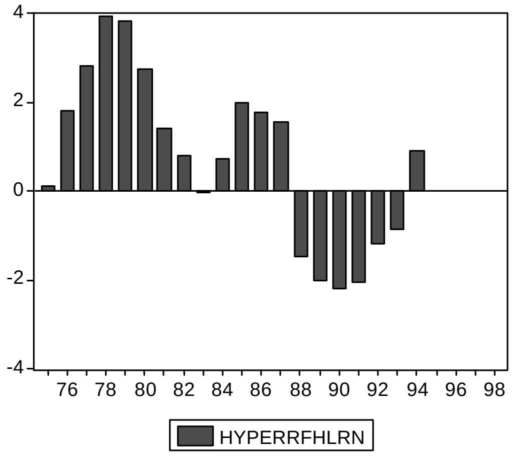

Figure 8: Errors in labor supply decisions of Fachhochschule students – with comparison to long run labor supply, [%].

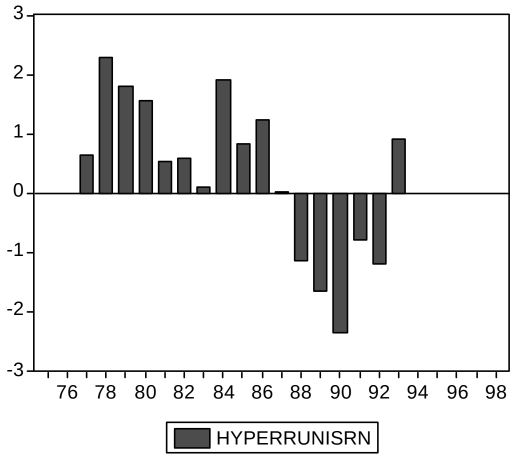

Figure 9: Errors in labor supply decisions of university students – with comparison to short run labor supply, [%].

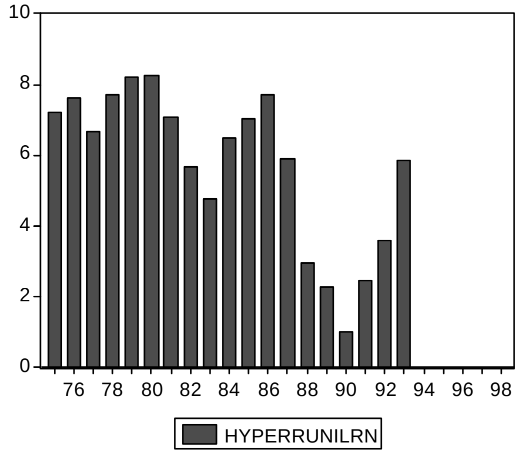

Figure 10: Errors in labor supply decisions of university students – with comparison to long run labor supply, [%].

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