Immigration, unemployment, and human-capital acquisition

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Introduction and Executive Summary

The following dissertation is a collection of four stand-alone research papers, written during my time as a research assistant at the University of Konstanz between may 2003 and october 2004 and during my time at the Justus-Liebig-University Gießen between november 2004 and december 2007. The focus of my research is on the interplay of immigration, native human-capital investment and the resulting consequences for the labour market outcome of natives and necessary implications for the immigration policy of the host country. Thus, we either consider educational decisions of natives and/or heterogeneous native agents to enlarge the existing analysis on the labour market impact of immigration.

In the following all four contributions are summarised to give a short overview on the respective research papers.

Chapter 1 is based on a research paper *The labour market impact of immigration: theory and evidence* which supplies an overview on the theoretical and empirical immigration literature. This paper compares the characteristics of the immigrant population and its labour market impact for the US and Germany. These countries have been chosen because of their significant differences in their immigration policies as well as in their immigrant population. While Germany has mainly focused on temporary immigration and has received a rather low-skilled immigration, the US immigration policy underwent several changes and thus received a bimodal immigration concerning skills.

Furthermore, the paper surveys the theoretical and empirical literature of the labour market impact of immigration. The theoretical literature does not come to a clear-cut result whether immigration is beneficial or harmful for the welfare prospects of natives. Depending on labour market institutions, the introduction of human–capital acquisition and/or the assumption of trade theoretical models may lead either to a positive, negative

or neutral impact of immigration. In contrast, the distributional effects of immigration are clear. Surprisingly, the empirical literature argues over these distributional effects of immigration. They argue over the impact of immigration on native wages and employment and find either a positive, negative or no effect at all.

Chapter 2 is based on the research paper *Immigration, education, and labour market institutions* which is co-authored by Benjamin Weigert. We focus on the distributional effects of immigration with an endogenous labour supply and unemployment in either competitive (as for the US) or rigid labour markets (as for Germany). We analyse how immigration of low-skilled workers may have contributed to higher wage differentials and lower unemployment of low skilled workers in the US and lower wage differentials and higher unemployment of low-skilled workers in Continental Europe. The classical theory of immigration tells us that, from a welfare perspective, immigration is beneficial for the host country under competitive markets and can serve as a disciplining tool in unionised labour markets. In our analysis, native labour supply of high and low skilled workers is formed endogenously by educational decisions of individuals with different abilities. The influence of immigration on the labour market is twofold: First, by affecting the relative wage, immigration directly increases the skill premium which is similar to the classical influence (a direct wage effect) of immigration. Second, a changing relative wage will induce natives to revise their educational decisions. Thus, immigration alters the existing relative stocks of high- and low-skilled workers which translates into a further relative wage change. This impact on relative wages induces natives to enter higher education. This will modify the ability composition of the respective educational groups. We show that immigration of low-skilled labour magnifies the aforementioned classical wage effect if the level of education is sufficiently high in the host country. However, with a lower level of education, this direct effect is likely to be compensated. The basic mechanism of magnification or compensation remains valid even when we account for rigid wages. In this economic environment the change of the skill premium is accompanied by an increase of unemployment of low skilled worker

Chapter 3 is based on the research paper *Immigration policy, equilibrium unemployment, and underinvestment in human capital* which is also co–authored by Benjamin Weigert. In this chapter, we analyse the impact of different immigration policies on native human capital investment in a search-theoretic model of the labour market. This class of model features unemployment and underinvestment in human capital and the analysis of flows rather than stocks. We show that skill-selective immigration policy aiming at

high-skilled immigrants (as, for example, in Australia or Canada) leads to rising educational attainment of natives and can be Pareto-improving. In combination with appropriate education subsidies, underinvestment in human capital can be removed such that a Pareto-optimal investment level of natives is reached. Including separated labour markets of different skill groups allows us to discuss explicitly immigration which is bimodal with respect to skills (as in the US).

The last chapter is based on the research paper *The impact of immigration on local labour markets reloaded*. We focus on an empirical puzzle of the existing literature. By measuring over local labour markets in the US, most of the empirical studies only find a negligible effect of immigration however certain local labour markets (like Los Angeles) have received massive inflows of immigrants. The latest explanation is that instead of wages and employment, the technology used by firms has adapted to the existing labour supply: thus, unskill biased technological change (cf. Lewis (2003)). We show in a search-theoretic model with three different skill groups (high- and low-skilled natives and low-skilled immigrants) that the result of Lewis is a special coincidence of the number and the skill endowments of immigrants entering the US. Furthermore, we combine the existence of skill biased technological change with the proposed unskill biased technological change of Lewis. We include a possible impact of native out-migration.

Einleitung und Zusammenfassung

Die vorliegende Dissertation basiert auf vier verschiedenen Forschungsarbeiten. Diese Forschungsarbeiten entstanden während meiner Tätigkeit als wissenschaftlicher Mitarbeiter an der Universität Konstanz von Mai 2003 bis Oktober 2004 sowie an der Justus–Liebig–Universität Gießen von November 2004 bis Dezember 2007. Alle Arbeiten befassen sich im weitesten Sinne mit der Wirkung von Immigration auf die Arbeitsmärkte des Gastlandes unter der Berücksichtigung der Ausbildungsentscheidung einheimischer Arbeitskräfte. Dabei konzentrieren sich die Arbeiten auf das daraus resultierende einheimische Arbeitsmarktergebnis (bspw. Löhne und Arbeitslosigkeit) sowie die einheimische Immigrationspolitik. Wir erweitern damit die bestehende theoretische Immigrationsliteratur um entweder einheimische Ausbildungsentscheidungen und/oder heterogene Individuen.

Im folgenden wird ein kurzer inhaltlicher Überblick über die vier verschiedenen Forschungsarbeiten gegeben.

Das Kapitel 1 ist ein Übersichtsartikel mit dem Titel *The labour market impact of immigration: theory and evidence* der die theoretische und empirische Literatur zum Einfluss von Immigration auf einheimische Arbeitsmärkte zusammenfasst und diesbezüglich die USA mit Deutschland vergleicht. Die Länder weisen starke Unterschiede sowohl in der Immigrationspolitik als auch in ihrer Immigrantenbevölkerung auf. Während Deutschland sich jahrelang auf temporäre Immigration konzentriert hat und damit hauptsächlich gering qualifizierte Immigration angezogen hat, haben die USA mehrere Male versucht ihre Immigrationspolitik auf die Bedürfnisse ihres Landes auszurichten und damit eine bimodale Bildungstruktur bei ihren Immigranten erhalten.

Die theoretische Literatur über den Einfluss von Immigration auf die einheimische Wohlfahrt kommt allerdings zu keinen klaren Ergebnis, ob Immigration nun die

Möglichkeiten Einheimischer fördert oder hemmt. Die Ergebnisse, die dabei entweder einen positiven, negativen oder neutralen Effekt darstellen, hängen sowohl von den berücksichtigten Arbeitsmarktinstitutionen, der Einführung von Ausbildungsentscheidungen Einheimischer als auch der Betrachtung verschiedener handelstheoretischer Ansätze ab. Die verteilungstheoretischen Wirkungen von Immigranten sind allerdings unumstritten. Überraschenderweise streitet aber genau darüber die empirische Literatur, wobei es hier eine Tendenz zu keinem Einfluss von Immigration gibt, andere Studien aber einen negativen oder positiven Effekt finden.

Dem Kapitel 2 liegt eine gemeinsame Forschungsarbeit mit Benjamin Weigert zugrunde, die den Titel *Immigration, education, and labour market institutions* trägt und sich mit der Verteilungswirkung von Immigration im Gastland befasst. Wir thematisieren dabei Immigration im Zusammenhang mit den unterschiedlichen Entwicklungen auf angloamerikanischen und kontinentaleuropäischen Arbeitsmärkten bei endogener Lohnstruktur und Arbeitslosigkeit. Wir untersuchen, inwieweit sich der starke Anstieg des qualifikatorischen Lohndifferentials bei gleichzeitig niedriger Arbeitslosigkeit in den USA sowie geringere Veränderungen der Lohndifferentiale bei ausgeprägtem Anstieg der Arbeitslosigkeit vornehmlich im Bereich gering Qualifizierter in Kontinentaleuropa als Folge der Einwanderung gering qualifizierter Arbeitskräfte erklären lassen. In der theoretischen Literatur über den Einfluss von Immigration gilt als klassisches Ergebnis, dass Immigration vorteilhaft für die heimische Ökonomie ist. Dies gilt sowohl für Arbeitsmärkte mit vollkommener Konkurrenz als auch bei gewerkschaftlich organisierten Arbeitsmärkten, auf denen insbesondere die Immigration von gering Qualifizierten disziplinierend auf Gewerkschaften wirkt. Unser Ansatz betont einen weiteren Wirkungskanal der Immigration, über den der eben zitierte bekannte direkte Einkommenseffekt von Immigration auf die Lohnstruktur der Einheimischen tendentiell verstärkt wird. Immigration induziert zusätzliche Ausbildung und führt damit zu einer Änderung der Qualifikationsstruktur der Gesellschaft, was wiederum auf Lohnstruktur und Arbeitslosigkeit zurückwirkt. Um die Auswirkung von Einwanderung unter den jeweils vorherrschenden institutionellen Verhältnissen darzustellen, wird für die USA ein flexibler Lohn, für die Länder Kontinentaleuropas – deren Arbeitsmärkte sich u.a. durch einen starken Einfluss von Gewerkschaften auszeichnen – ein fixer Mindestlohn angenommen. Im Falle flexibler Löhne erzeugt die Änderung der Ausbildungsentscheidung eine Verstärkung des direkten Lohneffekts, was die beschriebene Entwicklung in den USA beschreibt. Im Fall rigider Löhne wird der direkte Lohneffekt durch

die Änderung der Ausbildungsentscheidung nur gering verstärkt oder sogar kompensiert, dafür wächst allerdings die Arbeitslosigkeit unter den geringqualifizierten Einheimischen. Wandern dagegen hochqualifizierte Arbeitskräfte zu, sinkt im Fall der rigiden Löhne überraschenderweise die Arbeitslosenzahl, während gleichzeitig die Ausbildungsanreize für die Einheimischen zurückgehen.

Auch dem Kapitel 3 liegt eine gemeinsame Forschungsarbeit mit Benjamin Weigert zugrunde. Der Titel der Arbeit lautet *Immigration policy, unemployment, and underinvestment* und befasst sich mit der Frage welchen Einfluss Immigration auf die Bildungsinvestitionen von Einheimischen hat, wenn der Arbeitsmarkt durch Suchfriktionen gekennzeichnet ist. Suchfriktionen auf dem Arbeitsmarkt führen im allgemeinen zu Arbeitslosigkeit und zu einem ineffizienten Niveau der individuellen Bildungsinvestitionen. Die Analyse zeigt, dass eine selektive Einwanderungspolitik, die auf gut ausgebildete Einwanderer ausgerichtet ist, verstärkte Bildungsinvestitionen bei Einheimischen zur Folge hat. Damit kann eine derart ausgestaltete Politik zu Pareto-Verbesserungen bzgl. der Bildungsentscheidungen der Einheimischen führen. Durch Kombination der Einwanderungspolitik mit geeigneten Ausbildungssubventionen für einheimische Arbeitskräfte ist sogar eine vollständige Beseitigung der Ineffizienz der Bildungsinvestitionen und die Realisation des Pareto-optimalen Bildungsniveaus möglich. Zusätzliche Differenzierung von verschiedene Qualifikationsgruppen am Arbeitsmarkt erlaubt eine Diskussion des Einflusses von bimodaler Immigration auf das Gastland. Eine derartige Differenzierung ist erforderlich, um die Konsequenzen der existierenden Immigration in den USA und Deutschland adäquat zu untersuchen.

Dem Kapitel 4 liegt eine Forschungsarbeit mit dem Titel *The impact of immigration on local labour markets reloaded* zugrunde. In diesem Kapiel beziehen wir uns auf ein Rätsel der empirischen Immigrationsliteratur. Diese mißt den Einfluss von Immigration auf Löhne und Beschäftigung in den US oft über lokale Arbeitsmärkte hinweg und findet üblicherweise nur einen vernachlässigbaren Einfluss von Immigration, obwohl einige lokale Arbeitsmärket wie Los Angeles sehr hohe Zuwächse in den Immigrantenzahlen aufweisen. Die neueste Erklärung dieses nicht vorhandenen Einflusses ist, daß sich die Produktionstechnologie und nicht die Löhne angepasst hätten (vgl. Lewis (2003)). Das Arbeitsangebot bestimmt alos die Technologiewahl der Firmen was in Gebieten mit hoher Immigration zu technologischen Wandel hnisichtlich gering Qualifizierte geführt hätte. Wir zeigen in einem suchtheoretischem Rahmen mit drei Ausbildunsgruppen (einheimische, gering Qualifizierte und hoch Qualifizierte sowie gering qualifizierte Immigranten), daß die Ergebnisse von Lewis nur aufgrund einer besonderen Kombination

von Anzahl und Ausblidungsstand der Immigranten zustande gekommen sein könnten. Außerdem verbinden wir in unserem Modell skill biased mit unskill biased technological change im gleichen Arbeitsmarkt, was zu den empirischen Ergebnissen von Lewis führt. Weiterhin führen wir noch die Möglichkeit der einheimischen Auswanderung als Reaktion auf Immigration ein.

CHAPTER 1

The labour market impact of immigration: theory and evidence

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1.1 Introduction

Immigration is one of the most heatedly debated issues in politics. The rising immigrant numbers and the resulting fears of the native population have led to more restrictive immigration policies in many industrialised countries. Most of the native's reservations regarding immigration are based on distributional arguments, that is, that immigrants will replace native workers which will result in higher native unemployment rates and/or lower wages. However, the theoretical and the empirical economic literature does not arrive at these clear results. To the contrary, the economic literature on immigration concludes that immigration can be beneficial, harmful or can even have no effect at all on the labour market prospects of natives. Everything depends on which theoretical model or empirical study one believes.[1]

We will concentrate in this survey on the impact of immigration on different labour market institutions: competitive versus rigid labour markets. Therefore we will review the different theoretical models and the results of empirical studies from two prototypes of immigration countries, the US and Germany, which are characterised by the aforementioned labour market institutions. The US (like Canada or Australia) is a traditional immigration country whereas for most European countries immigration is a rather new phenomenon. A further difference are the existing labour market institutions in both countries: US labour markets are typically thought as competitive while in Germany wage rigidities are generated by, for example, collective wage setting by unions.

There are further important issues of the impact of immigration on native welfare that this survey does not cover. For example, we are only concentrating on the effects of legal immigration. Taking into account illegal immigrants could generate more negative or positive effects of immigration on native welfare.[2] Another important strand of the literature focuses on the impact of immigration on the welfare system (taxes and pensions) and thus the provision and distribution of unemployment benefits, as well as on the political decision making in the host country.[3] Furthermore there is rising literature in economics that concentrates on native attitudes towards immigrants.[4] The structure

[1] Obviously, there are already several well-known surveys of this literature such as Greenwood and McDowell (1986); Borjas (1994); Friedberg and Hunt (1995); Zimmermann (1995) and LaLonde and Topel (1996), which cover parts of this survey.

[2] See Yoshida (2000) and Yoshida and Woodland (2005) for an overview.

[3] See Boeri et al. (2002), Razin and Sadka (2005) and Kemnitz (2006) for recent overviews.

[4] See Mayda (2006); O'Rourke and Sinnott (2006); Dustmann and Preston (2006) among others.

of the survey is as follows: first, we describe the immigrant population in the receiving countries; second, we summarise the theoretical literature on the labour market impact of immigration; and third, we provide an overview of the empirical studies.

In section 1.2, we will summarise the stylised facts on immigration and provide a short history of immigration since the Second World War for both countries. The similarities between the US and Germany are the increased number of low-skilled immigrants and the increased number of refugees. The differences are their recognition of the increasing immigrant flows and the different immigrant population concerning the educational attainment of immigrants. In both countries, immigrants often have often higher unemployment rates, less education and earn lower wages. However, in the US, we find much more heterogeneity with regards to immigrants' education levels and their success on the labour market. In contrast, the German immigrant population does not show this bimodality because there are very few highly skilled immigrants.

In section 1.3, we will provide an overview of the theoretical explanations of the effects of mostly low-skilled immigration on the labour market outcome of natives. We consider the different theoretical results of immigration on wages or employment of natives depending on either the existence of competitive or rigid labour markets in both closed and open economies. In closed economies and under competitive markets, immigration theory predicts that immigration results in an overall gain for natives. The same result holds if we open this kind of economy to international trade: immigration leads as international trade in goods to an overall gain. But in the long run, international trade theories as well as labour markets including union behaviour or exogenous minimum wage legislation may reverse this result and lead to a non-existing or even negative effect of immigration. Furthermore there are substantial and clear-cut distributional effects from a theoretical viewpoint. These effects are often more decisive for a certain immigration policy than the question of the overall gain or loss of immigration in a country. Thus, the advice for politicians range from no migration at all, to creating migration barriers, to implementing wage subsidies to offset the negative effect to laissez-faire immigration. As the theorists are undecided, the empiricists may have a clearer answer.

Therefore, in section 1.4, the empirical literature on the labour market impact of immigrants will be reviewed. Unfortunately, the empirical literature also argues about the effect of immigration, specifically in regards to the distributional effects of immigration. As in the theoretical literature, it seems to be a question of the model used. Apparently,

adherents of local labour market studies believe in the rather non-existing or quite modest effect whereas national labour market supporters see a clear negative effect. And most surprisingly, the newest studies even show a positive effect of immigration on native wages. Interestingly, most of the studies are concerned with the US labour market. In Germany there are far fewer studies, although there are rather heated debates about this issue.[5] Section 1.5 will conclude with a comparison of the theoretical and empirical results.

1.2 A brief history and stylised facts

1.2.1 A brief history of US immigration

The history of immigration into the US is very well documented.[6] According to Clark et al. (2007) there are mainly two periods of immigration after 1945: before and after the *Amendments of 1965 to the Immigration and Nationality Act of 1952*. Before the Immigration Act, immigration was directed by quotas which preferred more or less European – especially British and German – immigrants.[7] After the abolition of these quotas, immigrants mostly came from three geographical areas: Asia, Latin America and Western Europe. However, besides the end of the quota system, American politicians still tried to foster immigration of Western Europeans by establishing family reunification as main source of immigration. They expected high chain migration induced by the existing large European immigrant communities. But instead of Western Europeans, Latin-American and Asian families used this tool to let immigrate their families. Therefore, the *Immigration Act of 1965* lead to a quite dramatic change in the source countries: the fraction of Western Europeans on the population of immigrants dropped by nearly 25 per cent which were gained by Asians, Caribbean and Mexicans. Several authors – e.g., Borjas (1994) – see this evolution as a reason for the declining human capital of immigrants. Furthermore, with this policy change, the proportion of the foreign-born population on the total population rose to about 8 per cent from about 5 per cent in the 1970s.[8]

A further important cut on the foreign-born population was the *Immigration Reform and Control Act (IRCA)* from 1986. Intending to dispose illegal immigration, all existing

[5] See Longhi et al. (2005) for an overview of the large cross-country and cross-study variance.

[6] See Hatton and Williamson (1998, 2005) among others.

[7] These quotas dated back to the *Immigration Act of 1921* and its *Amendment of 1924*.

[8] Interestingly, this proportion of the foreign-born is still below the 15 per cent in the beginning of the 20th century.

illegal immigrants fell under the offer of an amnesty, but new illegal immigration should be avoided by imposing penalties on employers.[9] The *Immigration Act of 1990* had no significant impact on the composition of the foreign-born population. The difference between the foreign-born population and recent immigration flows are depending on the different characteristics of the main source countries. The huge and steady inflow from Mexico significantly changes the assimilation process of immigrants (concerning, e.g., language proficiency). Another legal platform to enter the US is the *Refugee Act of 1980* which followed the *Refugee Act of 1952*. Under this law, all immigrants fearing persecution because of political, ethnic or religious reason are allowed to immigrate. Examples for large refugee inflows are the Mariel boat lift from Cuba, the subsequent immigration from Cuba and the boat people from Asia.

1.2.2 A brief history of German immigration

Since the Second World War, the German experiences with immigration can be divided into four periods:[10] The first period (1945 – early 1960s) was the war adjustment phase where about 12 million Germans left the former German territories in Eastern Europe. From 1950 to 1960, about 90 per cent of the population growth has been by refugees from Eastern Europe. Until the Berlin wall was erected in 1961, another important stream of immigrants (about 2.6 millions) came from the German Democratic Republic into the Federal Republic of Germany. Surprisingly, the huge immigration flows nearly had no negative effect on the labour market because the rapid growth of the economy (*Wirtschaftswunder*) absorbed the massive inflows. Due to their German ethnicity, this first wave of immigrants obviously differs in their possibility to a more or less easy integration from the following waves.

The second period (1960 – 1973) is made up by the so called guest-worker system. Germany introduced an open immigration policy with active recruitment of workers in South European and Mediterranean countries because of regional and sector-specific labour shortages of low-skilled labour during the boom period. The ancestor of the following treaties was concluded with Italy in 1955 and involved the equality of treatment

[9] In fact, the IRCA didn't lead to any significant decrease in the number of illegal immigrants (cf. Orrenius and Zavodny, 2003). See Jasso et al. (2000) for the economic impact of the US immigration policy.

[10] See Herbert (2001); Bauer et al. (2005) among others. The German historical development is often comparable to the immigration experience of the other European countries with only one difference: the immigration source has been the decolonisation which several European countries had to face (cf. Zimmermann, 1995). The overview concentrates exclusively on West Germany as East Germany have not had any significant immigration (cf. Herbert, 2001).

concerning wages and social insurance payments between immigrants and natives. Immigration was mainly seen as positive for the German economy which used immigration as mobility reserve of labour for peak times. By not prolonging labour permits in recessions, unemployment has been exported in the recessions of the early 70ies. The immigration figures rose steadily from 700.000 to 4.1 millions foreign-born workers until 1973. From the mid 1960s on, the residence time of immigrants increased significantly, the number of women and children grew and the employment rates therefore decreased steadily. Thereby, these waves of immigrants still constitute the composition of the German stock of immigrants today.

In the third period (1973 – 1989), after the first oil price shock and the starting recession, the recruitment and open immigration policy came to a hold. The German government followed three principles: cutting down the number of new immigrants, integration of the existing immigrants and promotion of return migration. This policy strengthened the compositional change of immigrant population: there were more children, women and older immigrants instead of the former young male guest workers. The unemployment rates now were above average, because immigrants were mostly low-skilled and the low-skilled intensive sectors were mainly hit by the recession (e.g. metal industries, mines, construction and textile industries).

At the end of the 1980s, family reunifications decreased and new motives of migration appeared: the last period is dominated by the breakup of the communism and the rise of asylum seekers. Especially in the years of the Yugoslavian civil war or the conflict between the Kurdish and Turkish population in Turkey, Germany received most of the refugees. Besides that, Germany allowed the immigration of Eastern Europeans who were of ethnic German origin.[11] As Germany didn't regard itself as an immigration country, there was no guideline to reorganise immigration considering the needs of the German state and economy. With the immigration law of 1993, the number of asylum seekers decreased rapidly, because they could be sent back if they had immigrated from a safe third country, and the social benefits for immigrants were largely cut down. In 1999, the *Staatsbürgerschaftgesetz* removed an important obstacle for the integration of foreigners in Germany: it was possible to acquire the German nationality after 8 years of residence or as a child of immigrants with its 18th birthday. In 2001, the first immigration law was provided with directed search for migrants who might be needed in Germany.

[11]These immigrants do not count as immigrants in official German statistics. There is actually no official category as foreign-born in European statistics, which causes problems for the empirical evaluation for countries like France and the UK (naturalised immigrants) or Germany (cf. Zimmermann, 1995).

1.2.3 Today's immigrant population in the USA and Germany

We will discuss the current economic status of the immigrant population within five categories: (un-)employment, labour force participation, self-employment, wages and education. In each section we will show the stylised facts of the immigrant population in the US and compare these with the respective situation in Germany.

(Un-)employment status of immigrants In general, immigrants (male and female) have higher unemployment rates compared to US natives. The unemployment rates are lower for the elder immigrants and unemployment rates are much higher among immigrant women relative to immigrant men. Obviously, the unemployment rate also depends on the educational attainment of immigrants. The immigrant groups are divided in one part with low unemployment rates and high employment rates (Europeans, Canadians, Asians and Africans) and a second part with the opposite characteristics (Latin Americans, especially Mexicans and Caribbean). This bimodality holds for all following categories (cf. Chiswick and Sullivan, 2005)

Immigrants are employed in the private sector more than in government agencies, but the negative government agency bias disappears with the duration of stay (rising naturalisations) and as English-proficiency increases. Again, Mexicans have the lowest rates of government employment and Asians the highest. The occupational distribution is nearly the same for native and immigrant men, but differs largely among immigrant and native women. The Western Europeans, Canadians and Asians are largely represented among managerial or professional occupations, whereas the Mexicans and other Latin Americans are mainly occupied in operative and laborer jobs. The often-cited claim that immigrants take jobs which natives do not want to do cannot be documented in general (cf. Chiswick and Sullivan, 2005).

In the 1960s, the unemployment rate of immigrants was still lower in Germany but this changed at the start of the recession in the early 1970s. The German government introduced a law prioritising the hiring of natives (*Inländerprimat*). Today, the overall unemployment rate of immigrants is higher than the respective unemployment rate of natives: an unemployment rate of 19.1 per cent for foreigners compared to 10.8 per cent for natives in 2002 (cf. Bauer et al., 2005). Interestingly, we cannot find the bimodality of unemployment experiences as in the US. In Germany, all groups except the Spanish immigrants have higher unemployment rates, with the Turkish community experiencing the highest unemployment rate (23.6 per cent). The employment structure is generally

the same as in the US. Most of the immigrants – especially the guest workers and the ethnic Germans – work either in operative and laborer jobs while natives work more in managerial positions. Immigrants are employed mostly in the construction, mining and service sectors. The decline of these sectors may be one reason for their higher unemployment rates.

Labour Force Participation The labour force participation rate of US immigrant men is slightly higher (89 per cent) than the labour force participation rate of native men (87 per cent). But the difference in the labour force participation between immigrant and native women is in favour of the native women (70 per cent vs. 63 per cent).[12] Next to gender, the duration of residence also matters for the labour force participation. Immigrants have higher participation rates with higher duration, because elder immigrants have invested more into US-specific skills through, such as language or on-the-job-training. In fact, after five years of residence most of the immigrants have adjusted their labour force participation.

The labour force participation rates in Germany are comparable to these of the United States. The rate of native men and women is about 82 per cent and 70 per cent, respectively. The overall rate of immigrant men is about the same as for native men but the rate for immigrant women is much lower than for native women (cf. Velling, 1995). The larger gap in the participation rate of women can be explained by the high labour force participation rate of women from East Germany who already had high participation rates relative to West Germany.

Self-employment In the past, the self-employment rates for US immigrants (16 per cent) were higher than for natives (10 per cent). That has changed to nearly the same self-employment rates (cf. Chiswick and Sullivan, 2005). Borjas (1986) explained the differences in self-employment probabilities between immigrants and natives with the concentration of immigrant groups in certain geographical areas. This enclave effect, as Borjas calls it, is due to the better understanding of tastes and language by self-employed immigrants compared to natives. Natives have therefore a natural disadvantage in certain self-employment industries.[13] This difference is especially obvious for the self-employers in the food and service sector. In an extension of the model of Borjas (1986),

[12]The differences in the gender labour force participation rates maybe explained by e.g., the marital status, schooling or children (cf. Chiswick and Sullivan, 2005).

[13]The enclave effect is supported by Lofstrom (2002) whereas Yuengert (1995) finds no such effect.

Borjas and Bronars (1989) show that minorities (instead of immigrant groups) should have overall lower self-employment rates, their self-selection in self-employment is negative and their income from self-employment is lower than for respective natives. They explain these patterns by consumer discrimination and the enclave effect mentioned above. Interestingly, the groups of the Black and Mexican minorities follow their predictions, but the Asian minority follows more the characteristics of the white native reference group.

In Germany, the general tendency (for natives and immigrants) to be self-employed is lower than in the US. Natives have a self-employment rate of about 12 per cent and immigrants only have a self-employment rate of nearly 7 per cent. These figures are even more surprising when we take into account that self-employed immigrants earn a lot more than comparable salaried immigrant workers in Germany.[14] A further difference to the US is that the shapes of the age-earnings profiles are similar for immigrants and German natives. The reasons to become self-employed such as the avoidance of unemployment, are the same in both countries (cf. Constant and Zimmermann, 2004, 2006).

Wages The characteristics of the wage earnings development in the US are described by the seminal paper of Chiswick (1978). Usually the age-earnings profiles of immigrants are steeper than for natives: immigrants have lower wages in the beginning, catch up over a period of 10 to 15 years and often end up with even higher wage earnings than comparable natives. This development is explained by higher incentives to invest in country-specific human capital and positive self-selection of immigrants. Nevertheless, the development of immigrant earnings is rather controversial: the pattern of catch-up by Chiswick was first-time questioned by Borjas (1985, 1995a). Borjas uses a within-cohort analysis and finds a relative decline of wages of subsequent immigrant cohorts and no complete convergence of wages between immigrants and natives. He attributes the decline of educational attainment by immigrants as a reason for the decreasing assimilation of immigrant earnings. In contrast, Chiswick (1986) and more recently Card (2005) disagreed on the often expected decline in immigration educational attainment and show that the catch–up of immigrants earnings is still present. Still, the divergence between different source country groups is rather high: Europeans, Canadians

[14] As in the US, the respective immigrant groups partly differ in their attitudes concerning self-employment, for example, the Turkish community are twice likely to be self-employed compared to other immigrant groups (cf. Constant et al., 2006).

and Asians earn more than Mexicans or other Latin Americans. And it will be the former groups who catch up or even overtake the respective group of natives.

The literature on (the convergence of) wage earnings of immigrants in Germany is extensively surveyed by Bauer et al. (2005). Apparently, immigrant earnings in Germany do not show the same kind of convergence as in the US. In particular, guest workers show either no or very little wage adjustment over time. Dustmann (1993) explains this difference by the temporary character of migration due to the guest worker system. Temporary immigrants will invest less in human capital and are often negatively selected. In comparison to the second large group of immigrants in Germany – the ethnic Germans – the differences are even more surprising: Bauer and Zimmermann (1997) and Schmidt (1997) report no significant initial earning gap between ethnic and native Germans and nearly the same age-earning profiles as native Germans. The reason for this fast assimilation is a higher investment in country-specific human capital.

Education In general, immigrants are characterised by lower educational attainment compared to natives. Within the group of immigrants, educational attainment of men is higher than that of women. The proportion of the highest educational attainment (more than 16 years of schooling) is the same among immigrants as among natives but the group with the lowest educational attainment is significantly larger among immigrants than natives. Interestingly, Chiswick and Sullivan (2005) find no large variation concerning the arrival date, but a strong dependence on the source country. The change in the source countries of the recent decades influences the overall education as well as the dispersion of education. Thus, the two main sources of immigration – Asia and Latin America (mainly Mexico) – lead to a bimodal distribution: very high and homogeneous educational attainment among Asians and very low educational attainment of Mexicans.[15] Besides schooling, language is an important factor for the assimilation of immigrants as higher language proficiency leads to a better labour market outcome and better integration of immigrants. The bilingualism of immigrants (a second language is spoken at home) is again highest among Mexicans and Asians and less important among Europeans and Canadians. The latter communities report also the highest proportion of a very well English-fluency. Not surprisingly, the language-fluency increases with the duration in the US.[16] Germany's immigrants aren't characterised by a bimodal

[15]See Borjas (1994). The differences between the ethnic communities can be also shown by their school enrollment rates (cf. Hirschman, 2001).

[16]See Rivera-Batiz (1990) and Chiswick and Miller (1995, 1999) on studies for the US, Berman et al. (2003) on evidence for Israel and Dustmann and Fabbri (2003) on evidence for the UK.

distribution of education: the overwhelming part of the guest worker (and also ethnic Germans but they show faster assimilation to the Germany-specific human capital) are low-skilled, high-skilled immigration is quite low. One explanation of the missing high-skilled immigrants in Germany is the guest-worker system. It has attracted mostly temporary immigration which is low-skilled and had no incentive to invest into human capital. Thus, the difference in human capital investments between different immigrant groups may be explained by the different return propensities (cf. Dustmann, 1999). The language proficiency of German immigrants exhibits the same characteristics as the language proficiency of the US immigrants (cf. Dustmann, 1994).

We have shown how the different immigration policies of both countries have shaped the composition of the immigrant population. Furthermore we have seen the differences in the existing immigrant population. In the next section, we will review the theoretical explanations how immigration influences the labour market outcome of natives – considering different labour market institutions.

1.3 The theoretical impact of immigration on labour markets

In this section, we will provide a general analytical framework to discuss several theoretical results concerning the impact of immigration on labour markets in the host country. Basically, we distinguish two kind of models, namely models with competitive labour markets and models with rigid wages. We start with the presentation of a competitive economy where the number of goods and factors are the same and, as a special case, we will analyse the well-known Heckscher-Ohlin model (HO model). We continue with the uneven cases of fewer goods than factors where we analyse the Berry-Soligo model (one good and two factors), and the Ricardo-Viner model (two goods and three factors) or fewer factors than goods where we look at the special case of a continuum of goods. Furthermore, we will show the Ricardian framework as well as increasing returns. After providing an analysis of competitive economies, we will introduce rigid wages and reconsider the impact of immigration.

1.3.1 Competitive factor markets

General framework

We will give a general theoretical framework in which we discuss different theoretical models of the impact of immigration on native wages and employment.[17] Our starting point will be the so called *integrated world equilibrium* where factors are fully mobile across countries and product and factor markets are fully competitive. We consider an economy with N goods and M factors and identical technologies across countries. Assume that production of these goods can be described by a concave and linear homogeneous production function $y_i = f_i(v_i), \quad i = 1, ..., N$ where $v_i = (v_{i1}, ..., v_{iM}), \quad i = 1, ..., N$ is the vector of factor inputs. The vector of factor prices is $w = (w_1, ..., w_M)$. The corresponding unit-cost function can be written as:

$$c_i(w) \equiv \min_{v_i \geq 0} \{wv_i \mid f_i(v_i) \geq 1\}.$$

$c_i(w)$ describes the minimum cost to produce one unit of output. After applying Shepard's lemma, we get the factor intensities or the optimal factor demand for each factor: $\partial c_i / \partial w_j = a_{ij}(w)$.

Under perfect competition on goods markets, firms generate zero profits, resulting in the following zero-profit conditions:

$$p_i = c_i(w), \quad i = 1, ..., N. \tag{1.1}$$

Combining the zero-profit condition with the full employment conditions and by inserting $\partial c_i / \partial w = a_i(w)$ in $v_i = y_i a_i(w)$, we get the factor market equilibrium condition:

$$\sum_{i=1}^{N} a_{ij}(w) y_i = V_j, \quad j = 1, ..., M, \tag{1.2}$$

with V_j as the endowment of factor j. Finally, consumer preferences are homothetic and identical across countries and we get the goods market equilibrium condition:

$$y_i^W = D_i^W(p_i), \quad i = 1, ..., N, \tag{1.3}$$

[17] Most of the following exposition is based on Trefler (1997) or Feenstra (2004).

where the world demand D_i^W for good i must equal the world production of this good. The three equilibrium conditions, (1.1), (1.2) and (1.3), can be solved by the following triple: $w = w^*$, $p = p^*$and $y = y^*$.[18]

Suppose we analyse the case of the same number of goods and factors. The most common type of the models with the identical number of goods and factors is the 2×2 Heckscher-Ohlin (HO) model, with $M = N = 2$. In this setting and if factors are free to move between sectors, factor prices are equalised and thus only depend on world endowments of factors.

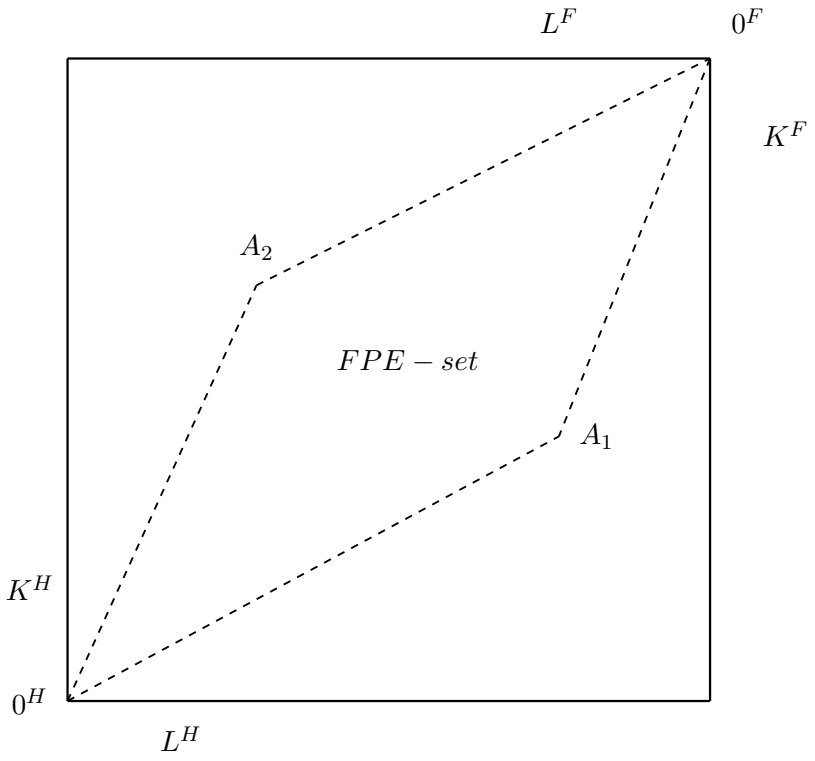

Figure 1.1: The factor-price equalisation set.

These factor world endowments are shown in figure 1.1 on the vertical and horizontal axis for two factors (labour and capital) and two countries (home and foreign). Including the total factors used in production of good i, we get $A_i = a_{ij} D_i^W$. Summing these up gives the factors used in world production. We can show that in the parallelogram

[18]See Dixit and Norman (1980) and Woodland (1982) as classic references.

$0^H A_1 0^F A_2$ in figure 1.1, both countries produce both goods (the cone of diversification for both countries) and factor price equalisation occurs even without any factor mobility:

$$V_j = \{v \mid v_i \leq a_{ij}(w^*)y_i, \quad 0 \leq y_i \leq y_i^*\},$$

which is the set of possible distributions of v over countries that is compatible with (w_i^*, y_i^*) although factors are not mobile internationally. That is the important result that trade in goods can substitute for trade in factors which is due to the export of e.g., the labour-intensive good by the labour-abundant country.[19]

Now, we analyse how the factor-price equalisation set changes if we have either more or less goods than factors. We start with the case of more factors than goods ($M > N$). The most common models are the Berry-Soligo-model (2×1) and the specific-factors-model (3×2). In general, we can conclude that factor price equalisation is unlikely to occur in these kind of models. Usually, a change in the factor endowments leads to a change in factor prices so that the input coefficients a_{ij} will change.

In the case of less factors than goods ($M < N$), V_j has a positive measure. Suppose we have the situation of an economy with three goods and two factors ($M = 2 < N = 3$). We have then three first-order conditions and two unknowns which give us no explicit solution. According to different price vectors which allow for zero profits, there are either multiple solutions for the outputs of the three sectors or specialisation in two of three sectors. Under the assumption of an integrated world equilibrium and market clearing for the goods and factor markets, we get a factor-price equalisation space where the national outputs are undetermined. Beyond the factor-price-equalisation space, specialisation in the goods production leads to a determined production structure if factor prices differ between countries. This solution can be reached if we concentrate on endowment differences of the countries: the capital-rich country has to specialise in the production of the capital-intensive goods.[20] In the following section, we will analyse the welfare and distributional effects of immigration under factor price equalisation or without factor price equalisation.

[19] We are not considering here the debate in international trade theory if trade liberalisation leads to less factor mobility. See Venables (1999) for an survey on this topic.

[20] See Dornbusch et al. (1980) for a model with two factors and a continuum of goods.

Migration within the factor-price equalisation set

Under factor price equalisation, there are the same wages in all countries and thus there are no incentives to migrate at all. The resulting immigration surplus is zero and there are no distributional effects of immigration. If we would abandon the assumption of an integrated world equilibrium, we may consider, for example, a small, open and fully diversified economy. In this case, an inflow of immigrants will lead to an increase in the output of the sector which uses this input intensively and decreases the output of the other sector. This result is summarised by the Rybczynski theorem. Thus, immigration wouldn't lead to any wage or aggregate employment changes of native workers.

Trefler (1997) shows that these results are robust against technology or input quality differences between countries. He shows, that under the assumption of a constant returns to scale productivity measure, factor price equalisation holds for productivity adjusted wages. In the case of costly factor and goods movements in the same type of model, Venables (1999) can explain that trade liberalisation may reduce the immigration flows through a reduction of the factor-price differential.

Migration without factor price equalisation

First, we analyse the case of fewer goods than factors ($M > N$). We are especially concentrating on the aforementioned models: the Berry-Soligo model that has one sector and two factors and the Ricardo-Viner (or specific-factors) model with two goods and three factors.

One-sector model

In the theoretical literature based on labour economic approaches, one-sector models are often used, which generate different results from the multisector models.[21] We present an open economy but one gets the same results if one would consider a closed economy or a large country such as the US (see Borjas (1995b, 1999)). Introducing $M = 2$ factors (suppose one factor L is labour und one factor capital K) and one sector $N = 1$, Borjas (1995b, 1999) shows that the benefits of immigration for natives depend on

[21]Most of the following analysis is based in the seminal paper of Berry and Soligo (1969). They show that the first immigrant who arrives in the host country receives her marginal product and has no impact on native welfare. But the following immigrants still receive their marginal product but lower the wage for each intramarginal immigrant. Generalisations of the model of Berry and Soligo are Wong (1986) and Quibria (1988). The first result of the impact of a marginal immigrant was introduced by Grubel and Scott (1966).

whether natives are capital owners and whether immigrants have complementary capital endowments as natives. First we consider the case where immigrants do not bring any capital with them. The total income of the host country, excluding immigrants, is given by $Q = rK + wL$. The price of output will be the numéraire meaning that factor prices are measured in output prices. With perfect competition on factor and goods markets, marginal products equal marginal costs: $w = f_L(L, K)$ and $r = f_K(L, K)$. With an additional inflow of immigrants M, the aggregate labour supply will be increased by $\Delta L = M$ which leads to a wage reduction from w to $w^{'}$.

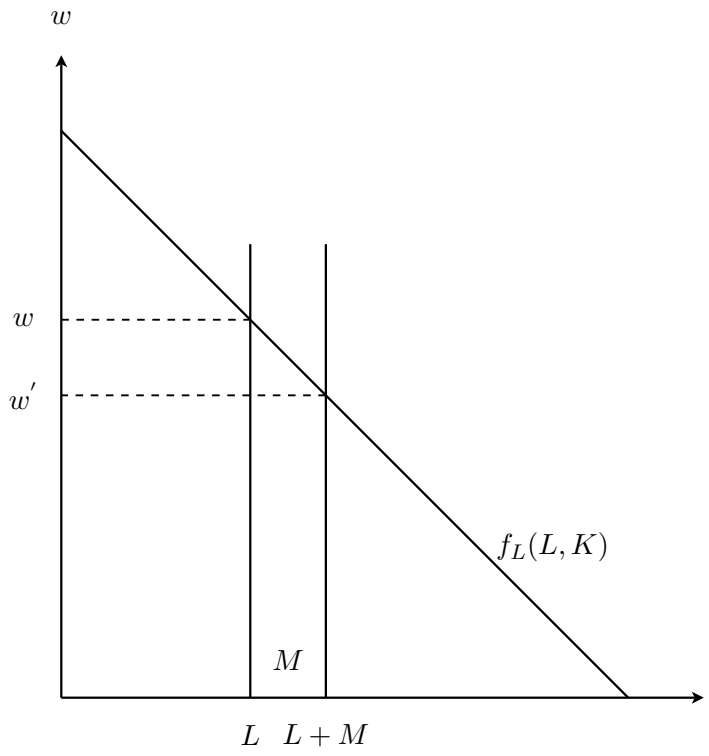

Figure 1.2: The immigration surplus of a one-sector economy.

In figure 1.2, the $f_L(L, K)$ curve denotes labour demand and the vertical line that originates in N depicts labour supply before immigration. The equilibrium wage before immigration is then given by w. With the inflow of $\Delta L = M$ immigrants, labour supply shifts outwards. The respective equilibrium wage is therefore reduced from w to $w^{'}$. Native wage income will fall from wN to $w^{'}L$ but the difference of $(w - w^{'})L$ will be distributed to native capital owners. The depicted triangle in figure 1.2 shows the resulting immigration surplus of the native population.

The major difference from the two-sector model is that now factor prices depend on factor endowments: the wage falls with an increasing number of immigrants in the host country. The influence of immigration is a redistributive effect: the aggregate welfare of the native population will rise but the gains accrue only to native capital owners while native workers experience a reduction in wages. The result changes if we consider that immigrants take capital with them to the host country. Immigrants who enter the host country with as much capital as natives own will replicate the existing economy. Thus, the resulting immigration surplus would be zero.

Furthermore the immigration surplus depends on the elasticity of the labour demand curve. What happens to the immigration surplus if we weaken either the assumption on the elasticity of the labour demand curve? If the labour demand curve would be perfectly elastic (which results from the diversified production structure), immigration have not had any influence on the native wage and immigrants would receive the resulting immigration surplus. [22]

Now let us consider the case of three factors $M = 3$ one sector $N = 1$: high-skilled labour L_H, low-skilled labour L_U and capital K which is mobile across countries. Both immigration surpluses (either for the case of purely high-skilled immigration or purely low-skilled immigration) are positive so that it is not clear if a country should admit high- or low-skilled immigrants. Borjas (1995b) argues that the immigration surplus of high-skilled workers should be higher because the elasticity of the factor price for high-skilled labour is larger for high-skilled workers than for low-skilled workers. An economic explanation for this higher elasticity is that high-skilled labour should be complementary to the factor capital. Typically, there should be also an opposite effect: if the native population is mainly high-skilled, the substitubility of high-skilled immigrants may compensate the positive immigration surplus from the complementarity of production of high-skilled labour and capital. For countries like the US and the UK, which are characterised by competitive labour markets and mostly low-skilled immigration, immigration is positive for the overall native population, but capital owners and high-skilled natives gain while low-skilled natives lose.[23] As in Berry and Soligo (1969), the theoretical welfare analysis of Borjas would imply a laissez-faire immigration policy. The

[22] See Borjas (1999) for a detailed derivation of this result.

[23] The picture of the benefits of immigration may be different if the immigration surplus would include any transfers as, e.g., social service payments. The gains or losses from the use of transfer payments are also debated in the literature (see Borjas (1994) for an overview on the literature and Lofstrom and Bean (2002) on the recent development).

model of Borjas clearly shows the distributional consequences and the possible welfare gains of immigration for a native labour market. But in an economy with an endogenous labour supply in which immigration will affect the educational decisions of natives, the distributional consequences depend on the host country's level of education and the educational endowment of immigrants (see Lumpe and Weigert, 2004). Focusing on skill premia, immigration may influence the educational decision that the resulting skill premia would be compensated and therefore leading to lower wage inequality.

Specific-factors model

In the specific-factors model, we change the assumption of factor mobility between sectors: one factor will be now sector-specific. Assuming $\bar{K}_i$ as a sector-specific input, L will still be mobile across sectors. We get a different equilibrium condition from the general framework:

$$p_i = c_i(w, r_i), \quad i = 1, 2,$$

where factor prices for the factor K will not be the same across sectors.[24] In this case, and considering the same good price as well as technologies for both countries, factor-price equalisation will be quite unlikely. In the short run, the factor prices for capital between both sectors, r_1 and r_2, are different due to the sector specifity of the factor capital. Furthermore, for an increase in the endowment of the mobile input (e.g. immigration), the Rybczynski theorem does not hold. Specifically, sectors do not expand asymmetrically but both expand.

In figure 1.3, the revenue belonging to sector 1 is then the area O_1TEL_1 and the income generated by labour is O_1wEL_1. Obviously, the same holds for sector 2. If $\Delta L = M$ immigrants arrive, the wage decreases to $w^{'}$ to accommodate the increased labour supply but the interest rates and the output for both sectors increase. The areas A and B in figure 1.3 are the immigration surplus which shows the shift of income from labour owners to the owners of the sector-specific input. Immigration will be beneficial for the host country, as in the case of the one-sector model. We get the same effect as in the one-sector model: a host country's welfare rises by the immigration surplus. Obviously, the home country also gains from immigration.

In the case of more goods than factors, the production structure is determined through specialisation in a range of goods by each country (cf. Dornbusch et al. (1980)).

[24] We could also say that capital supply is totally inelastic.

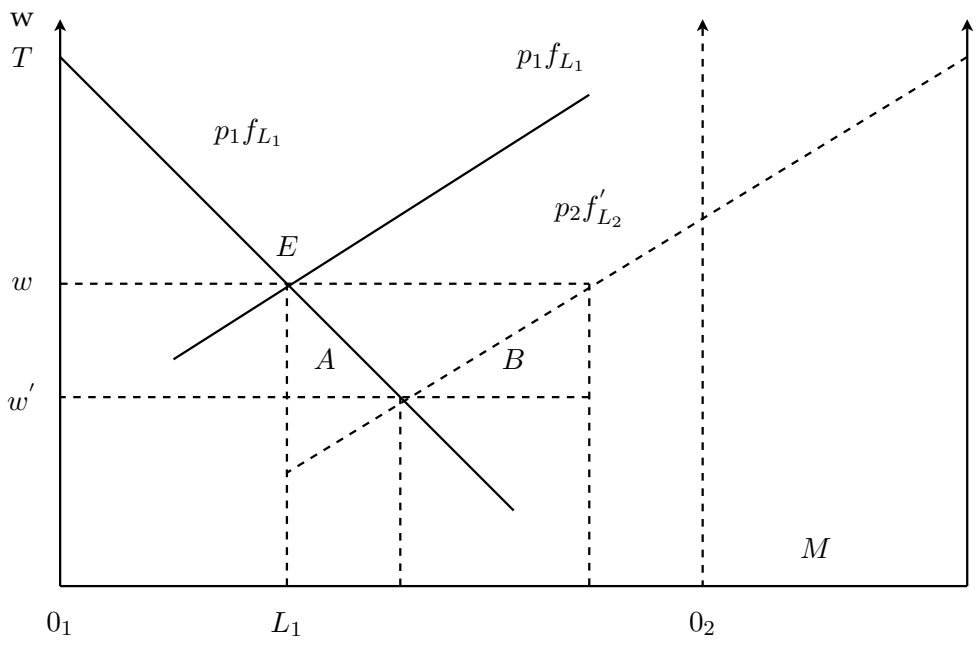

Figure 1.3: The immigration surplus in a specific-factors model.

In this model, we can not exactly say which kind of influence immigration has on native welfare.

Ricardian model

Trefler, 1997 analyse the effects of immigration in a Ricardian model of the Dornbusch-Fischer-Samuelson type (cf. Dornbusch et al., 1977).[25] For the ease of exposition, we limit the analysis to $N = 3$ sectors. The only input is now labour and we assume that the host country only produces good 1 while the origin country produces the other two goods. To produce one unit of output, we need $a_i, \quad (i = 1, 2, 3)$ units of labour. We get long run zero profits by equalising the price of the good p_i to the cost of producing one unit of the good: $w/p_i = 1/a_i$. The goods are ranked according to the following index (asterisks denote the foreign country):

$$a_1/a_1^* < a_2/a_2^* < a_3/a_3^*.$$

[25]Findlay (1982) was the first to analyse the impact of immigration using a Ricardian model.

Suppose that the host country produces only the first good. If immigration takes place, all immigrants will be employed to produce good one, which leads to an excess supply of the first good. The home trade deficit drives down home wages until $w/p_2 = 1/a_2$. Thus, the wage in the host country is driven down until it can also produce the second good. In contrast to the foreign country where the production of the second good will shut down because of rising wages. The resulting immigration surplus is negative as the wage for producing the second and third goods have fallen and the wage for producing the first good will be constant. One example of this could be agriculture, an industries that survives only because of the existence of immigrants.

Davis and Weinstein (2002) introduce a Ricardian model in which labour of the home and the foreign country are not identical. Both type of labour are divided by a productivity measure. The productivity of labour in the home country is higher than in the foreign country. Immigration takes place if the host country has a technological superiority in all of the respective factors (e.g., the US). They argue that this kind of immigration leads to high income losses of natives and the source countries will receive all of the gains from immigration. Felbermayr and Kohler (2007) combine the wage effect of Borjas (1995b), the terms-of-trade effect of Davis and Weinstein (2002), and endogenous goods prices into a general framework. They can show that the terms-of-trade effect dominates the other effects if immigration inflows are small. Furthermore they demonstrate that repatriation of immigrant income, in combination with a non-tradable goods sector, may have an important influence on native welfare.

Increasing returns to scale

If one introduces increasing returns to scale (that are external to the firms, to preserve a competitive economy) and takes labour as the only input in a model situation with two countries and two goods, the first result is that immigration increases native productivity. The increasing labour force in the host country increases the productivity and welfare of natives. A second effect is the expansion of the output which leads to lower prices that, in turn, negatively shifts the terms of trade and reduce natives' welfare. The trade-off between both effects generates an optimal immigration level. Immigration enhances welfare when the number of immigrants is small compared to the native population; however, for large native workforces or large immigration flows, the effect of immigration is negative.

1.3.2 Introduction of rigid wages

The analysis in the previous section focused on competitive labour markets where wages are flexible. There is considerable consensus among labour theorists that these conditions plausibly match those of the Anglo-Saxon labour markets. Continental labour markets, however, are often characterised by rigid wages and resulting unemployment. Wage rigidity may be caused by minimum wage legislation, union wage setting, search frictions or efficiency wages. When analysing of rigid labour markets, we may also discuss the effects of immigration on unemployment, that are emphasised in public debates.

We will start with an analysis of Davis (1998) who introduces immigration and rigid wages in our general framework from the former section: the integrated word equilibrium. With the introduction of a minimum wage and thus unemployment in Europe, he analyses the impact of immigration on US welfare. He shows that the effects of immigration may not take place in the host country (in his case the US) but in another part in the world (Europe): Davis' insulation hypothesis. In his model, an exogenously given rigid wage in Europe determines all factor and good prices in both parts of the world rsulting from the under the assumption of a full diversified production structure.[26] This result stems from the zero-profit conditions (cf. (1.1)) in which the minimum wage $\bar{w}$ must be supported by an appropriate goods price $\bar{p}$. The only possible way of adjustment to immigration into the US from a third country (e.g., Mexico) is therefore a compensation through the European and US production structure: hence through the European unemployment rate and exactly offsetting Rybczynski-effects. Hence, figure 1.4 shows the factor-price equalisation set where the level of European unemployment is depicted by the line $0^{EU}U$.

[26]There are other models which exhibit an exogenous minimum wage. Brecher and Choudhri (1987), for example, extend the Berry-Soligo-framework by including international trade in goods. Furthermore they introduce a minimum wage by a unemployment insurance financed by a lump-sum tax system. In this case, the high wage (capital-abundant) country will follow a no-immigration policy as optimal immigration policy.

Another possibility to analyse unemployment resulting from an institutionally set minimum wage is the well-known Harris-Todaro model (cf. Harris and Todaro (1970) and Ghatak et al. (1996) for a survey of this literature) which considers rural-urban migration. In this model, an expected higher wage in the urban sector will lead to immigration from the rural sector. Immigration and unemployment will coexist as long as the expected urban wage is higher than the rural wage. To reduce unemployment, the government either has to pay wage subsidies or introduce migration barriers. Therefore several authors have focused on the effects of immigration on labour markets where unions dominate the wage-setting behaviour. In the context of the Harris-Todaro model, Calvo (1978) extends this framework by allowing unions to negotiate wages with firms. But he still needs the migration barrier to increase native welfare. Bhagwati and Srinivasan (1974) and Corden and Findlay (1975) show policy measures which allow for free migration in this type of model.

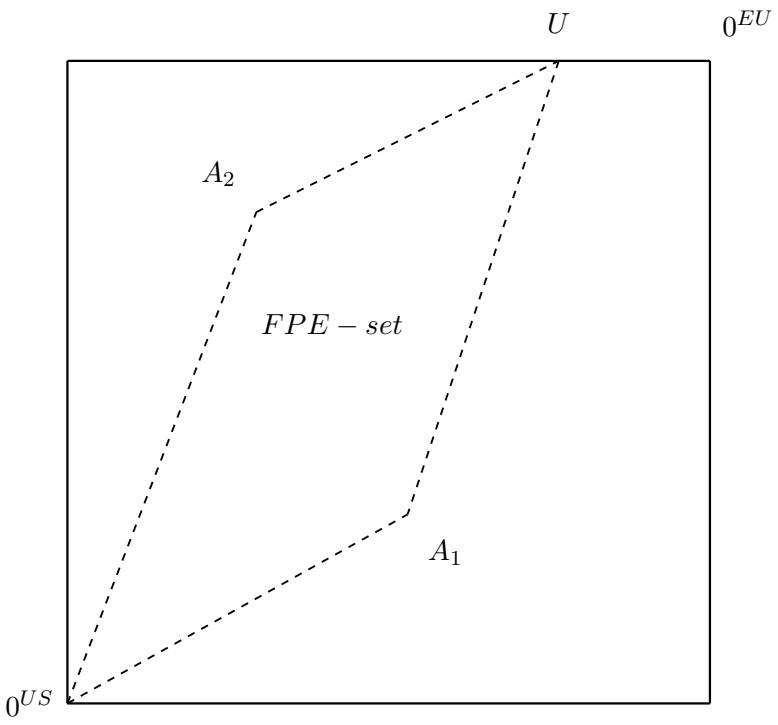

Figure 1.4: The factor-price equalisation set and unemployment.

Therefore the impact of low-skilled immigration into the US would be seen in a rise in the European unemployment rate instead of a US wage reduction. Put it differently, under constant goods prices, immigration into the US results in excess supply of goods and rising unemployment in Europe without any immigration to Europe.[27] There are two problems of this model: the assumption of a fully diversified economy as well as the exogenous minimum wage.

Therefore we show now two type of models where the minimum wage is endogenous. In order to incorporate institutional features characterising German labour markets, Schmidt et al. (1994) and Fuest and Thum (2000) endogenise the wage by introducing minimum wage setting by a monopoly union or efficient bargaining. Schmidt et al. (1994) examine the impact of low-skilled mass migration on natives (high and low skilled) who are organised by a monopoly union. As in Borjas, the technology is a constant returns to scale production with three inputs: capital, low- and high-skilled labour.

[27]Meckl (2006) shows that the results of Davis (1998) change with the introduction of native educational decisions and labour heterogeneity, which results in a different minimum wage policy.

The assumption is that immigrants are substitutes in production for low-skilled natives, but complements to high-skilled natives. Immigrants do not bring any capital with them and they are not included in the union's objective function. The monopoly union sets the wages of low-skilled workers while employment is determined by firms. Both groups receive unemployment benefits which are financed by income and capital taxes. The union maximises the wage earnings of natives including unemployment benefits and negotiated wages. The objective function of the union is the sum of the wage bill of skilled and low-skilled workers and unemployment benefits. The effects of immigration in the case of a monopoly union are unclear: low-skilled immigration leads to replacement of low-skilled natives and to higher unemployment benefit payments by the government. But unions may negotiate lower wages to offset the replacement effect, leading to higher low-skilled native employment and higher wages of high-skilled natives. Still, the result depends largely on the substitubility/complementarity relation between the three inputs, the employment fraction held by natives or the consideration of immigrants in the union's objective function.

Fuest and Thum (2000) consider an efficient-bargaining model concentrating on firm-wide wage negotations.[28] The small open economy in their model has two sectors: a unionised and a competitive sector, where the technologies with two inputs – capital and labour – exhibit decreasing returns to scale. Immigrants work with a certain probability in the unionised sector and they bring no capital with them. Instead, all firms are owned by natives. The general effect of immigration is that it raises employment in the unionised sector because the reservation wage in the competitive sector declines. A declining reservation wage leads to a weaker position of unions in the wage bargaining process and therefore lowers wages in the unionised sector resulting in higher employment in the unionised sector. Unionisation and immigration then have two opposite effects on natives' welfare. The positive effect is the employment effect shown above, the negative effect is that immigrants are paid above their marginal product if they work in the unionised sector. The welfare effect of immigration largely depends on the wage elasticities of labour demand in the two sectors. If these elasticities are identical, both effects cancel out and we get the same result as for competitive labour markets. If the elasticity of labour demand is higher in the unionised sector then the overall welfare effect is positive. The employment effect in the unionised sector overcompensates the negative effect. If the elasticity of labour demand is higher in the competitive sector, only large

[28]This type of union behaviour is mostly known from Scandinavian countries and contrasts with more or less existing nationwide unions in countries like France or Germany. In particular, the full employment result does not match very well with German labour market properties.

and sustained immigration flows are beneficial. Immigrants are driving down wages, but natives overcompensate the wage losses by capital-earning gains.

As in the models for a competitive economy, the introduction of an endogenous labour supply through an educational decision of the native individual will change the exisiting results. Razin and Sadka (1995) present a model of endogenous human capital formation where immigration has a negative effect on native welfare. Fuest and Thum (2001) extend their previous model to discuss the effects of immigration on educational decisions and the respective labour market outcomes of natives. In their model, natives welfare increases with a certain amount of immigration. Mass migration has positive effects on the welfare of natives as it increases the number of skilled natives but a restrictive immigration policy (a low number of immigrants) will have a decreasing effect on natives welfare. Furthermore, Lumpe and Weigert (2004) show that immigration may have an increasing effect on wage inequality if we consider labour market rigidities in combination with an endogenous labour supply.

Besides minimum wage legislation or union wage setting, there have been other labour market institutions applied to the analysis of immigration such as labour contracts, efficiency wages, and search frictions. Labour contracts have been introduced by Ethier (1985) to model temporary migration in an international trade model. Mueller (2003) establishes a dynamic efficiency wage model with a dual labour market in a specific-factors model; while immigrants differ only in their positive probability with respect to returning to their home country from natives, he can show that immigrants are discriminated against by not receiving the good jobs. The segmentation of the labour market as well as the wage rigidity due the efficiency wages leads to a non-existing effect of immigration on native labour markets. The same way of modeling the differences between immigrants and natives has been used in a search-theoretic model by Lumpe and Weigert (2007). They demonstrate that underinvestment in human capital by natives (resulting from the hold-up problem) can be solved by a skill-selective immigration policy and thus is Pareto-improving. In combination with education subsidies, even a Pareto-optimal welfare level becomes attainable. However, Ortega (2000) was the first to introduce immigration in a search-theoretic model with two countries. In this setting, immigrants, natives and firms gain from migration.

Summarising the theoretical effects of immigration on labour markets and native welfare, we can conclude that there is no clear-cut effect. The models of competitive labour markets emphasise a positive welfare effect of immigration as well as a part of

the literature which concentrates on union-wage setting. Furthermore some studies suggest that immigration might increase native human capital investments. In contrast to these positive theoretical effects, trade theorists still argue these positive results since only negative, or no, effects (for competitive labour markets) can be seen. However, the distributional effects of immigration are clear-cut. Obviously, the US and Germany differ not only in their labour markets but in their social welfare systems as well. The large social welfare systems in Continental European countries might be another source of positive or negative effects of immigration on social welfare.[29] Therefore the literature cited in this survey tells only a part of the story.

1.4 Empirical evidence

In contrast to the theoretical literature, the empirical studies focus on the distributional aspects of immigration, for example, the impact of immigration on wages or employment of natives and do not concentrate on a welfare analysis of immigration. Interestingly, while the theoretical literature can predict clear-cut results on the distributional impact of immigration but can not predict these clear results for the impact on native welfare, the empirical studies address the distributional impact, for example, the impact of immigration on native wages and employment. There are three major results for the impact of immigration on native wages and employment. First, the studies of Card (2005) and adherents find only a modest negative impact of immigration on natives wages and employment which can be neglected. Second, Borjas (2003) and adherents find a significant negative impact and third, Ottaviano and Peri (2005) and Peri (2007) find a positive impact: so, everything is possible. In the following, we will discuss the different methods used and show their (dis-)advantages.

1.4.1 Local labour market approaches

We will start with the local labour market approaches as they were the first empirical studies that were conducted on the effects of immigration on native wages and employment. These studies measure the impact of immigration on wages and employment by utilising cross-sectional data from cities or counties (e.g. the SMSA in the US). They use labour markets with less or none immigration (as an extreme case) as counterfactual to the labour markets with high immigration rates. Thus, they regress wages or employment measures of natives on the immigrant densities in these labour markets. Their

[29] See Razin and Sadka (1995) and Wellisch and Walz (1998) among others.

results show a more or less negligible impact of immigration but the evaluation of local labour markets has been criticised for three different reasons:

- The location choice of immigrants is endogenous. The choice of immigrants maybe influenced by permanent region-specific effects such as the historic settlement pattern induces chain migration of following immigrant cohorts. Therefore immigration density and economic outcomes are correlated. A second reason for an endogenous locational choice of immigrants is that immigrants are attracted by local labour markets with higher wages caused by local demand shocks. This would lead to a downward biased estimate of the effects of immigration. The first problem of the permanent region-specific effects can be solved by taking differences-in-differences and thereby removing the region-specific effect. Thus, the empirical studies will relate changes in immigrant densities to wages over two points in time. The second problem of local demand shocks is solved by using historical settlement patterns as instrument variable because pre-existing immigration pattern should be uncorrelated with recent local demand shocks. Instead of using historical settlement patterns, we could also concentrate on cases where the allocation is exogenous.
- Due to immigration, natives may tend to migrate out of local labour markets – leaving the relative labour supply constant. The empirical analysis cannot identify the effect of immigration on wages which leads to an underestimation of the effect of immigration. The relevance of out-migration is not clear: Borjas (1999, 2003) regards it as serious problem while Card and DiNardo (2000) and Card (2001) find no out-migration. Possibilities for addressing these problems are either a two-stage estimation in which the first stage demonstrates that immigration does not lead to out-migration, or including out-migration into the regression as an omitted variable. These omitted variables have to be instrumented due to the correlation.
- Intercity trade and the induced Rybczynski theorem or factor price equalisation leave no effect on immigration if it is measured over local labour markets. The local economies may adjust by their output mix instead by reducing employment and /or wages but the economy as a whole should have a downward-sloping labour demand function.

The first study which used local labour market variations was Grossman (1982). She estimated a trans-log production function to derive elasticities of substitution between immigrants and natives. The measured impact of a 10 per cent increase in the number of

immigrants would result in a one per cent decrease of native wages. However, natives are not separated by skills. Borjas (1987) extends the analysis of Grossman by introducing different native groups (blacks, Hispanics, white, etc.). Furthermore he uses a Generalized Leontief production function and a different data set. He obtains the same result as Grossman for native earnings. Altonji and Card (1991) include instrument variables (the stock of immigrants) in their cross-section regression to control for an endogenous location choice of immigrants and estimate the effects of immigration on earnings and employment of minority groups and low-skilled natives. They find that a one per cent increase in the fraction of immigrants reduces employment opportunities of the respective groups by 0.25 per cent. Wages are reduced by this increase in immigration by 1.2 per cent. To get an upper bound of the impact on earnings, LaLonde and Topel (1991) estimate the effect of newly arriving immigration on older immigrants. They use the different cohorts of immigrants as different inputs and conclude that the impact on native wages is unimportant but newly arriving immigrants reduce wages of older immigrants. Taking into account the different labour market institutions, we would expect that the results may differ for the German labour market. Pischke and Velling (1997) apply the framework of Altonji and Card to West Germany. They confirm the same effects on native employment and wages as the US studies and a previous study of Velling (1995) for Germany. In contrast to these two studies are the results from DeNew and Zimmermann (1994) that show a detrimental effect of immigration on wages and employment. Pischke and Velling attribute these results of DeNew and Zimmermann to the different period examined. DeNew and Zimmermann used data from the 1970 to the beginning 1980s where a recession has taken place in Germany which has mostly hit the guest-workers concentrated industries.

Card (2001), again for the US, extends the existing models by including skill heterogeneity to measure the impact of the relative supplies of immigrants. He defines six occupational groups which are used as labour inputs in the underlying model. He corrects for local demand shocks by calculating the expected inflow rate of immigrants in the respective occupations on the basis of historical settlement patterns. Furthermore he controls for possible out-migration of natives due to immigration. Still, the results of the previous studies are proved robust. Employment and wages fall by about one per cent with an increase of ten per cent in the population share of a respective occupational group, only in high immigration areas (like Los Angeles and Miami) the impact might reach up to three per cent.

Controlling for local demand shocks and region-specific effects can be done most effectively in natural experiment settings where the allocation of immigrants is exogenous. Card (1990) examines the impact of the Mariel boatlift immigration from Cuba to Miami in 1980 which led rose the labour force of Miami by seven per cent. He compares the impact on wages and employment on different minority groups as well as native whites in Miami with five other cities in the US which are comparable to Miami concerning the industry structure. The resulting impact on wages and employment is negligible. Glitz (2006) uses the immigration of ethnic Germans into Germany in the late 1990s as quasi-experiments because these immigrants have been allocated exogenously over Germany by the government to guarantee an even distribution. But, like Card (1990), he finds no negative impact of immigration the labour market prospects of natives.[30]

The local labour market analysis by Lewis (2003, 2004) tries to explain the non-existent effect on wages and employment by a change either in the industry structure of local labour markets or by within technological change of firms in these local labour markets. Relying on the theoretical frameworks of Acemoglu (1998) and Beaudry and Green (2003), an increased supply of low-skilled labour will lead to the adaptation of different technologies to meet the local skill mix. Therefore the technical change in areas with high low-skilled immigration has slowed down. Furthermore he tests the Rybczynski-hypothesis (that the output of one sector but the factor prices stay constant) versus the aforementioned Acemoglu-hypothesis that production technologies adapts to the local factor mix.[31] He finds no effect of immigration on the industry structure or unemployment but a significant effect on the technology choice of firms. He concludes that the adaptation of firms to the existing input mix in local labour markets leads to a constant relative wage and employment.

All of the cross-sectional local labour market studies find a significant negative but only modest effect of immigration on wages and employment opportunities. Applying IV-methods generates stronger effects and differencing over occupational choice or skills leads, not surprisingly, to stronger effects among low-skilled natives. However, labour market institutions do not seem to matter as the results for Germany suggest.[32]

[30]Hunt (1992) uses the immigrant inflows of Algerian repatriates after the Algerian civil war as natural experiment while Friedberg (2001) concentrates on the Russian immigration towards Israel. Both studies analyse the impact of immigration inflows on national labour markets.

[31]See Hanson and Slaughter (2002) for an empirical study on the immigration induced Rybczynski-effect and factor price equalisation.

[32]In contrast, Angrist and Kugler (2003) find a negative effect of immigration in combination with less flexible labour market institutions.

1.4.2 National labour market

Wage inequality

Still, other authors do not belief in the solutions done by the local labour markets approaches to meet the problems of this method. Instead, they argue that the empirical analysis should concentrate on national labour markets to avoid the problem of out-migration. A first strand of literature constructs the counterfactual by simulation of an economy without immigrants. These studies are mostly concerned with the impact of immigration and trade on wage inequality in the US. This simulation method is based on pre-estimated parameters such as the elasticity of substitution between high and low-skilled labour. Therefore the underlying structural economic model (e.g. a CES production function) may influence the resulting estimates: different elasticities of substitution drive the results on the impact of immigration on wages and employment. Further problems of this method might be the assumption of perfect substitubility of immigrants and natives within each skill group and the right allocation of immigrants to skill groups.[33]

Borjas et al. (1992) have introduced this method (they call it the factor-proportion model) and find as result that immigration has not had any negative impact on college/high school wage differentials but has harmed the high school dropout earnings. The induced changes from trade and immigration in the relative skill composition of the US explain about 40 per cent of the relative wage decline of high school dropouts where immigration is the main source of the wage decline. Borjas et al. (1996) compare the local labour market approach with their simulation methods. They find that out-migration and industry structure assimilation lead to the non-negative effects of the local labour market approach, while their approach shows the detrimental effect of immigration and trade on low-skilled natives. Borjas et al. (1997) analyse the impact of immigration in a simulation based model from 1960 – 1990. They show that a large displacement effect of natives exists due to immigration and get the same findings as in their analysis of 1996 when researching the impact on wages and employment.

Skill-experience-cell approach

Borjas (2003) extends these models by including labour market experience differences between the respective immigrant groups because immigrants might not be perfect

[33]For example, high-skilled immigrants might work in low-skilled occupations in the first years after their arrival because of a lack of language proficiency.

substitutes in the skill groups. Immigrants are then allocated among different skill-experience groups and within these groups, immigrants are perfect substitutes to natives. Thus, native cell specific wages or employment measures are regressed on the immigrant share in the respective cells.[34] Obviously, problems arise if immigrants select into cells with better economic conditions. Another problem is the correct allocation of immigrants into the cells. Thereby, for an average native worker, immigration leads to a fall in wages of 3.2 per cent by an increase of ten per cent in the immigrant share. The most detrimental effect has been on low-skilled natives. The impact on wages for high-skilled natives, however, is only modest. Borjas (2005) implements a further critique – native out-migration – in a local labour model and compares it with the estimates of his national labour markets model. He claims that native out-migration explains 40 to 60 per cent of the existing wage impact differences concerning immigration, which stands in contrast to the evidence found by Card (2001).

Relying on the framework of Borjas (2003), Ottaviano and Peri (2005) focus on the impact on the average native workers instead of only low-skilled workers. They extend the model of Borjas (2003) in which they allow for imperfect substitutability of natives and immigrants within the skill-experience cells. Furthemore they allow for a certain degree of capital mobility while in the model of Borjas (2003), capital is always assumed to be perfectly immobile. They find immigration to be beneficial, because the average wage increased by three to four per cent for native workers due to immigration in the 1990s. Thereby, wages of low-skilled workers decreased by one per cent but those of high-skilled workers increased by four per cent. Peri (2007) extends this framework by including native out-migration and still receives a possible impact of immigration. Orrenius and Zavodny (2007) combine the empirical strategies of Borjas (2003) and Card (2001) and use a new data set that allows a separation of new arriving immigrants from already assimilated immigrants. They generate results on occupational wages comparable to Peri (2007): the impact on the occupational wages of high- and middle-skilled workers is positive while, the impact on the occupational wages of low-skilled workers is negative but small.

1.4.3 Summary

Card (2005) reviews the literature and critique on the local labour market approach and concludes that neither demand shocks, intercity trade nor out-migration of natives are

[34] The method is comparable to the analysis used by Card (2001).

responsible for the non-existing impact of immigration in local labour markets. He even argues that even in the time series approaches of Borjas, the effect of immigration should be modest: *While the counterfactual is unknown, it is hard to argue that the aggregate time series evidence points to a negative impact of immigration unless one starts from that position apriori.* (Card (2005, p. 321)). This result is also confirmed by new evidence of Lewis (2003) and Ottaviano and Peri (2005) who find no detrimental or even a positive effect on native wages and employment.

1.5 Conclusion

In this survey we have shown how the different immigration policies have shaped the different composition of the immigrant population in the US and in Germany. Both countries rather failed to implement a consistent immigration policy and most of the policies introduced had the adverse effect. Therefore the immigrant population is often characterised by higher unemployment rates and lower wages. The only large difference between both countries lies in the bimodality of skills among the immigrants of the US. Especially the Asian community supplies a large number of high-skilled workers which is absent in Germany.

From a theoretical point of view, the impact of immigration generates robust results concerning the distributional impact of immigration but is undecided on the welfare implications of immigration. In competitive labour markets, immigration is always beneficial if the economy is closed. For an open economy the results might reverse rather sharply. In rigid labour markets, the impact of immigration depends on the existing labour market institutions. An exogenous set minimum wage leads to a negative impact of immigration while unions may change their wage setting behaviour due to immigration and ask for lower wages. A further indirect but important impact of immigration might be on the educational attainment of natives.

The mixed results predicted by the theoretical literature carry over to the empirical studies. But in the empirical literature, the debate is on the distributional aspects of immigration and not on the welfare effects of immigration. Due to the different methods used, the impact of immigration on native wages and employment found by these studies differs largely. The impact on average wages is either small or positive (up to four per cent) but wages of native, low-skilled workers are decreased by either a modest one per cent or up to eight per cent. Still, it is interesting that neither the different labour market

institutions nor the different immigration concerning skills lead to different effects on native wages and employment for the US and Germany. We have not taken into account several other channels by which immigration may influence the welfare of natives. Apparently, the studies above include no illegal immigration which may enlarge a possible negative effect on low-skilled wages and employment. Finally, we have not considered any influence of immigration on the native welfare systems which may revise the results again.

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CHAPTER 2

Immigration, education, and labour market institutions

2.1 Introduction

Large and steady inflows of (il)legal immigrants into the US and Western Europe are a striking fact of the last four decades. While the workforce of those countries is relatively high-skilled, the overwhelming part of their immigrants are low-skilled workers.[1] In the classical literature on low-skilled immigration, it is shown that it raises native welfare in the host country as long as labour markets are competitive, though there might arise unintended distributional effects (cf. Berry and Soligo, 1969; Borjas, 1995). When labour markets are assumed to be not fully competitive as in the case of Continental Europe, the effect of immigration of low-skilled workers on native welfare depends on the actual labour market institutions. However, in both settings, it is shown, that the real income of those workers falls who directly compete with immigrants.

In contrast to these clear-cut theoretical results concerning distributional effects, the empirical evidence is somehow mixed: Borjas et al. (1997) and Borjas (2003) argue that the negative influence of immigration on the labour market outcome of natives is quite substantial. whereas Ottaviano and Peri (2005) argue for a substantial positive influence. However, many other studies find only a slight influence of immigration (cf. LaLonde and Topel, 1996; Card, 2001) or no influence at all (cf. Altonji and Card, 1991).[2]

In this paper we show that these unambigious distributional results do not hold if workers are heterogeneous and the educational attainment in the host country is endogenous. Our findings can be summarised as follows: Firstly, the impact of immigration on the measured skill premium of natives crucially depends on the level of the educational attainment in the host country. Immigration of low-skilled workers will induce different distributional effects for countries with different levels of educational attainment. Consequently, a country's "tradition" of immigration is also a relevant determinant for the labour market outcome for natives. Secondly, the influence of immigration on the evolution of the measured skill premium remains valid even with the introduction of wage rigidities.

In the early theoretical literature, immigration is modeled by assuming fixed labour endowments and competitive labour markets in the host country. Borjas (1995) shows

[1] See Borjas (1994) for legal immigration and Warren and Passel (1987); Espenshade (1995) for illegal immigration.

[2] The different results are perhaps due to the different empirical methods used and data in these studies. Card (1990, 2001) analyse the impact of immigration on local labour markets in the US whereas Borjas (2003); Ottaviano and Peri (2005) analyse the impact of immigration using aggregated data.

that immigration of low-skilled workers leads to an increasing wage inequality between high and low-skilled workers. Although the change in the wage income of high-skilled workers depends on the actual properties of the production technology. In case of q-substitubility, wage income of high-skilled workers will decrease while the opposite is true for q-complementarity. These results will not fully apply when the assumption of undistorted labour markets is removed. Schmidt et al. (1994) show that both – higher native unemployment or increased employment of low-skilled workers – might arise depending on the aforementioned q-substitutability or q-complementarity of low-skilled and high-skilled workers. Most important, with q-complementarity immigration of low-skilled workers may induce unions to lower their wage claim. In case of q-substitubility, wages of low and high-skilled workers might increase at the cost of increasing unemployment. Most related to our approach is the analysis of Fuest and Thum (2001) because they introduce an endogenous labour supply. Within an efficient bargaining model, they show that the reaction of the labour supply to the expected future immigration internalises the negative effect of immigration on the labour market outcome for workers. They get the result that immigration will lead to losses of (wage) income of low and high-skilled workers but increasing wage inequality between both groups. Since their result depends on the incorporated bargaining process, they do not provide results concerning unemployment.[3] In contrast, our approach does not rely on either the substitubility/complementarity of the respective factors, monoploy union behavior or efficient bargaining.

We introduce a general equilibrium model with heterogeneous individuals who decide on education and thereby forming the aggregate labour supply of low-skilled and high-skilled workers. Heterogeneity is introduced by an ability distribution. The skill premium – measured by the ratio of median or mean income between the educational groups – depends on the relative wage and on the ability composition of both groups. Hence, the influence of immigration on the labour market is twofold: Firstly, by changing the relative wage, immigration directly increases the skill premium. We call this channel the direct wage effect of immigration. Secondly, a changing relative wage will induce natives to revise their educational decisions. This will modify the ability composition of the respective educational groups and constitutes what we call the compositional effect of immigration. We show that immigration of low-skilled labour magnifies the aforementioned direct wage effect if the level of education is sufficiently high in the

[3]There are further contributions which endogenise the labour supply, e.g., Ortega (2005) in the context of a political economy model while Kemnitz (2004) in the context of a social welfare system.

host country. However, with a lower level of education this direct effect is likely to be compensated. The basic mechanism of magnification or compensation remains valid even when accounting for rigidity of wages. In this economic environment the change of the skill premium is accompanied by an increase of the unemployment of low-skilled workers. Furthermore, we show that countries with sustained low-skilled immigration have higher levels of education. We argue that these countries show a higher tendency for magnification of the skill premium. This remains true for countries characterised by rigid wages.

The remainder of the paper is organised as follows. In Section 2.2, we present the basic model, discuss the labour market equilibrium and our measure of skill premium. Immigration and its influence on the economy with flexible and rigid wages will be analysed in section 2.3. Section 2.4 concludes.

2.2 The model

2.2.1 Technology

We consider an economy in which competitive firms produce a single homogeneous consumption good Y using two different factors of production: high-skilled labour H and low-skilled labour L each measured in efficiency units.[4] The production technology $Y(H, L)$ is assumed to be neo-classical.[5] Normalising the price of the final product to one, profit maximisation leads to the following first order conditions:

$$\partial Y/\partial H \quad = \quad w_H, \qquad \partial Y/\partial L = w_L, \tag{2.1}$$

The marginal product for each type of labour equals the wage rate $w_i \quad (i = H, L)$ per efficiency unit of labour. Taken together, the first order conditions in (2.1) define the

[4]Capital as a third factor can be ignored as long as capital is assumed as perfectly mobile internationally with an exogenously given global interest rate. Otherwise the capital income of natives also depends on the relative inflow of immigrants and one has to analyse the wealth- and the wage distribution simultaneously. By ignoring capital as third factor, we are not concentrating on the issue of substitutability or complementarity of skill groups (cf. Borjas (1995)).

[5]This technology has to satisfy the following requirements: (i) $\partial Y/\partial i > 0$ and $\partial^2 Y/\partial i^2 < 0$ (ii) $\lim_{i\to 0} \partial Y/\partial i = \infty$ $\lim_{i\to\infty} \partial Y/\partial i = 0$ for $i = H, L$ (iii) $\gamma Y = Y(\gamma H, \gamma L)$.

aggregate relative labour demand $g(\omega)$ as a function of the relative factor price $\omega \equiv w_H/w_L$:

$$\frac{H}{L} = g(\omega). \tag{2.2}$$

Given our assumption on the production technology, the relative labour demand depends negatively on the relative wage ω: $g'(\omega) < 0$.

2.2.2 *Households*

Individuals are assumed to be heterogeneous with respect to their abilities a.[6] Abilities are continuously distributed on the support $[0, 1]$ according to a general density function $f(a)$. The total native population is normalised to mass one.

Given his ability a, an agent has to decide whether he invests in education or not. A worker with ability a without any further education supplies $(1 + a)$ efficiency units of low-skilled labour and earns a total wage income of $W_L(a) = (1 + a)w_L$. Alternatively he can spend an exogenously given fraction λ of time on further education, to supply $(1 + ba)(1 - \lambda)$ efficiency units of high-skilled labour. The parameter $b > 1$ measures the gross effect of education on marginal efficiency units of a trained worker with ability a. Hence, a trained worker earns a total wage income of $W_H(a) = (1 + ba)(1 - \lambda)w_H$.[7] We assume that both types of labour are *qualitatively* different: a low-skilled worker cannot work as high-skilled and vice versa. The wage for each skill group is a linear affine function of the ability a as depicted in figure 2.1.

Preferences are defined over the consumption of the homogeneous good Y and are identical for all workers. Thus, an agent maximises his total wage income and chooses to invest in training if his ability is higher than some threshold value t defined by:

$$(1 + bt)(1 - \lambda)w_H = (1 + t)w_L. \tag{2.3}$$

Workers with ability t are indifferent between investing in education or not. The threshold value depends on the relative factor price ω as well as on the exogenous parameters

[6] We interpret abilities as a mixture of innate abilities and knowledge acquired during compulsory schooling. The educational choice modeled in our paper is therefore a choice of further education.

[7] The model can be transfered into a dynamic framework if we would apply an OLG model: in the first period, the households would either acquire education (in the case of a high-skilled native) or work (as a low-skilled native). In the second period, both households would work and consume their life time income.

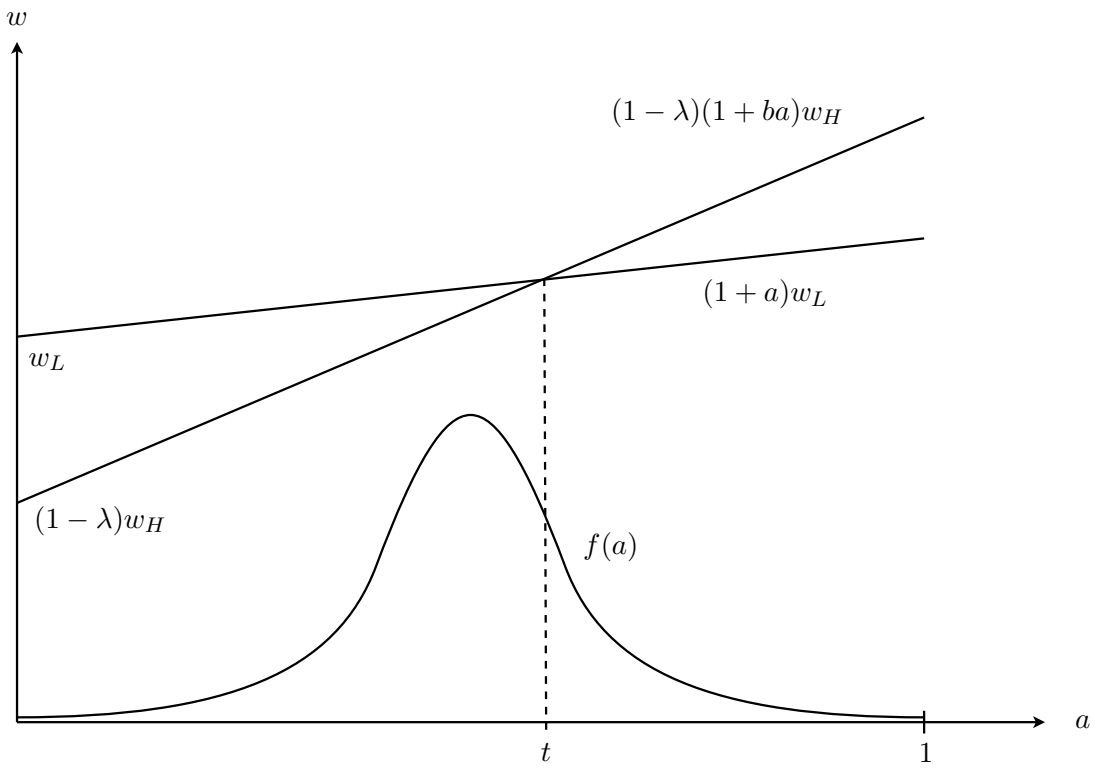

Figure 2.1: Determination of the threshold value $t(\omega)$

b and λ. Graphically the threshold is given by the intersection of the two wage functions (see figure 2.1) and can be calculated as:

$$t = \frac{(1-\lambda)\omega - 1}{1 - b(1-\lambda)\omega}. \tag{2.4}$$

The parameters b, λ and the relative wage ω have to satisfy the following condition: $2/(1+b) \leq (1-\lambda)\omega \leq 1$, such that t lies in the interval $[0,1]$. For the remainder of the paper we assume that this condition is fulfilled. If the relative wage changes, the threshold value changes according to:

$$t'(\omega) = \frac{(1-\lambda)(1+tb)}{1 - b(1-\lambda)\omega} < 0. \tag{2.5}$$

The rationale behind the negative sign is that a higher relative wage makes it favourable for agents with lower ability to invest in training. Even a small change in ω might result in a large reaction of t if the denominator is close to zero.

The economy's total supply of low-skilled labour and high-skilled labour corresponds to the weighted sum of efficiency units of the respective group and therefore depends directly on the training decisions made by households:

$$L(\omega) = \int_0^{t(\omega)} (1+a)f(a)da, \qquad H(\omega) = \int_{t(\omega)}^{1} (1-\lambda)(1+ba)f(a)da. \tag{2.6}$$

Obviously $L'(\omega) < 0$ and $H'(\omega) > 0$ since a higher relative wage decreases the threshold value thereby expanding the ability interval of the high-skilled workers while at the same time narrowing that of the low-skilled workers. Relative labour supply $h(\omega) \equiv H(\omega)/L(\omega)$ can be written as a function of the relative wage ω:

$$\frac{H}{L} = h(\omega). \tag{2.7}$$

Given the properties of the respective labour supply functions the relative labour supply is positively sloped: $h'(\omega) > 0$. The relative labour supply is determined by the structural parameters b, λ and the relative wage ω.

2.2.3 *Labour market equilibrium and the skill premium*

The properties of the relative labour supply and the relative labour demand guarantee a unique labour market equilibrium $\{\omega^*, (H/L)^*\}$ in terms of efficiency units.[8]

In order to discuss the influence of immigration on the income of individuals and the respective skill groups we need to define some wage measure. Because the economy is populated by heterogeneous agents, an unique wage does not exist for every skill group but a wage distribution for both groups. An apparent measure for the wage of the respective group would be the mean wage. But there is a major drawback in using the mean wage alone. The wage distribution of each group is a linear transformation of the assumed skill distribution, which turns out to be a skewed distribution. This can lead to over- or underestimation of the reaction of the representative wage. To address the problem, we also use the median wage as a representative wage.[9] We define the native's

[8] Throughout the paper asterisks denote equilibrium values.

[9] The ratio of the median/mean wage as a measure of premia of different skill groups has been used extensively in empirical research (cf. Greiner et al., 2004).

skill premium x as the ratio of the representative wage of high and low-skilled workers m_H and m_L:

$$x = \frac{m_H(t)}{m_L(t)} = \frac{m(w \mid a \geq t)}{m(w \mid a < t)} = \frac{(1 + bm(a \mid a \geq t))\,(1 - \lambda)}{1 + m(a \mid a < t)}\omega. \tag{2.8}$$

The skill premium is the product of two terms: The first term is the ratio of mean/median efficiency units of labour and the second term is the relative wage. Obviously, a change of the equilibrium relative wage ω resulting from immigration will change the skill premium directly via the second term. We call this change the direct wage effect. However, a change of the relative wage will also change the incentives to educate and thus the ratio of representative efficiency units. We call the change of the incentives to educate the compositional effect. As we will show, the overall impact of a change of the relative wage on the wage structure is ambiguous in general because both effects can offset each other. Figure 2.2 on the next page shows the labour market with LD denoting the labour demand and LS denoting the labour supply. Point A represents the labour market outcome without immigration.

2.3 Immigration and the labour market

2.3.1 Immigration under flexible wages

We model immigration as an inflow of efficiency units of labour denoted by H_I and L_I. We abstract from the consideration of the total number of immigrants entering the country and of the distribution of abilities among immigrants. To keep matters simple we assume that immigrants are not allowed to invest in education in the host country.

The influence of immigration on the labour supply is reflected by the immigration augmented labour supply function:

$$\frac{H}{L} = \frac{H_I + H(\omega)}{L_I + L(\omega)} \equiv h_I(\omega). \tag{2.9}$$

Using this representation allows us to discuss both the impact of first time ($L_I, H_I = 0$) and sustained immigration ($L_I, H_I > 0$). With exclusive low (high) skilled immigrants, the supply curve shifts to the right (left). But with both, positive immigration of low and high-skilled workers – which is the typical case –, the labour supply curve LS in

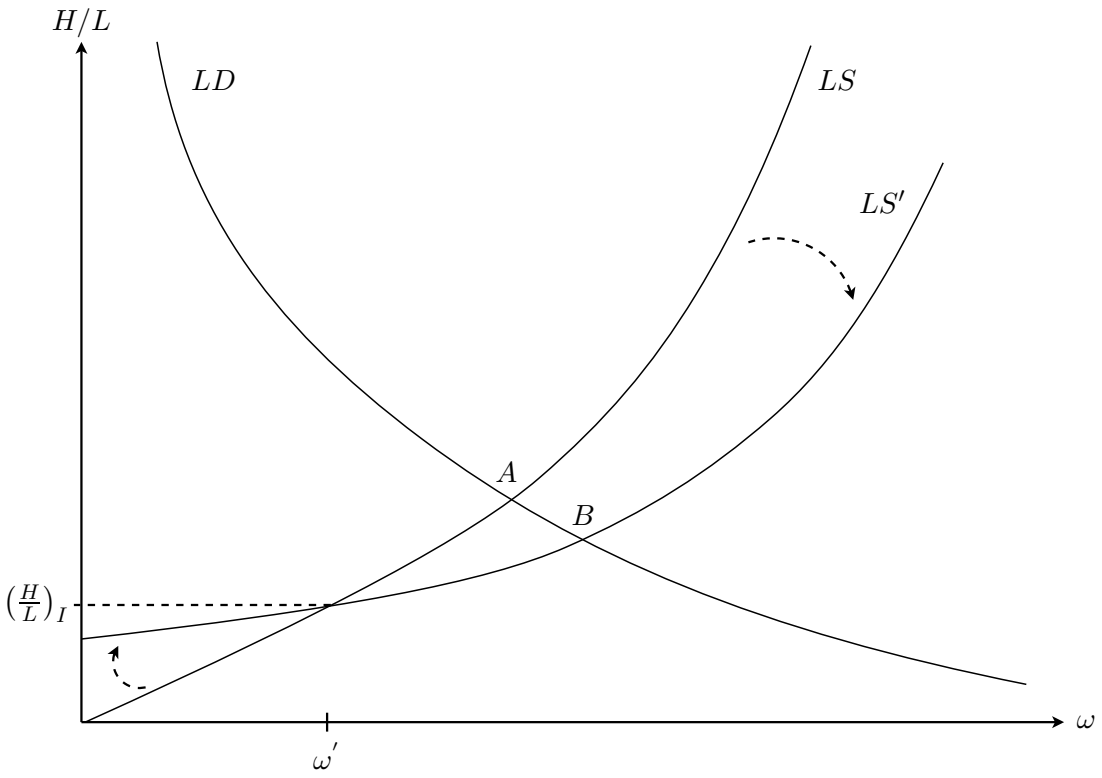

Figure 2.2: The labour market equilibrium with relatively low-skilled immigration

figure 2.2 will rotate clockwise around the point H_I/L_I, leading to a less elastic supply curve. The influence of immigration on the equilibrium relative wage ω^* can be derived as:[10]

$$d\omega^* = \frac{h_I(\omega^*)}{h_I'(\omega^*) - g_I'(\omega^*)} \left(\frac{dH_I}{H_I + H(\omega^*)} - \frac{dL_I}{L_I + L(\omega^*)} \right). \tag{2.10}$$

As the first term is always negative the second term determines the sign of $d\omega^*$: The equilibrium relative wage rate increases (decreases) if the immigration includes relatively less (more) high-skilled efficiency units in comparison to the existing equilibrium relative labour supply in the host country. This result is in line with the standard immigration literature summarised by Borjas (1999, 1995). As we are interested in the experiences made in the US or Western Europe, we limit the discussion to the case of relatively low-skilled immigration ($dH_I/dL_I < h_I(\omega^*)$) for the rest of the paper.[11]

[10] See the appendix.

[11] The case for immigration of low-skilled workers is even stronger if we take illegal immigration into account. For the US, at the beginning of the 1990ies the size of the population of illegal immigrants was

Due to heterogeneity of the labour force the change of the relative wage ω is not sufficient to discuss the distributional consequences of low-skilled immigration. We analyse the percentage change of the measured skill premium (2.8) to determine the distributional consequences of immigration. As indicated above the change of the skill premium can be decomposed into a direct wage effect and into a compositional effect. Thus the net impact of low-skilled immigration on the wage distribution is not as clear cut as it might seem at first sight. It crucially depends on the educational level in the host economy.

The elasticity of the skill premium $\varepsilon_{x,\omega}$ with respect to the relative wage change can be computed as:

$$\varepsilon_{x,\omega} = x'(\omega^*)\frac{\omega^*}{x(\omega^*)} = 1 - \left|t'(\omega^*)\right|\omega^* G(t^*), \tag{2.11}$$

$$\text{with } G(t) = \left(\frac{bm'_H(t)}{1+bm_H(t)} - \frac{m'_L(t)}{1+m_L(t)}\right).$$

The first term in equation (2.11) (the one) represents the direct wage effect by which the skill premium is influenced. The compositional effect ($|t'(\omega^*)|\,\omega^* G(t^*)$) stems from the fact that individuals react to the change of the relative wage. The sign of the compositional effect depends on the function $G(t)$ which measures the difference in the rate of change of the representative labour supply of the two educational groups. The sign of the function $G(t)$ is ambiguous in general. Hence the total effect of immigration on the measured skill premium is also ambiguous. As the threshold value is only another way of expressing relative labour supply, there are cases in which $G(t) < 0$ and immigration will magnify the direct wage effect.

In the following we will show that whether magnification $G(t) < 0$ or compensation $G(t) > 0$ occurs, will crucially depend on the initial relative labour supply and on the distribution of abilities $f(a)$.

estimated to be 3 Mio. people. . Most of this population was of Mexican origin, see Espenshade (1995) and Warren and Passel (1987). For estimates of the population of illegal immigrants in Europe see Entorf (2002).

The skill premium with symmetric and unimodal distribution of abilities

Assumption 2.1. *Abilities are distributed according to a symmetric and unimodal distribution with mean, median and modus at* $1/2$*. The following boundary conditions are also imposed:*

$$f(0) = f(1) = c \geq 0 \quad \textit{and} \quad \lim_{a \to 0} f^{'}(a) = -\lim_{a \to 1} f^{'}(a) > 0.$$

We will proceed as follows: Firstly, we calculate the compositional effect $G(t)$ for our two measures of the representative wage and show under which conditions the direct wage effect is magnified or compensated. Secondly, we discuss the difference between both measures and illustrate our findings.

The median ability of the low-skilled workers $a_L(t)$ and the high-skilled workers $a_H(t)$ are defined by:[12]

$$a_L(t) \equiv F^{-1}\left[\frac{F(t)}{2}\right], \quad a_H(t) \equiv F^{-1}\left[\frac{1-F(t)}{2}\right].$$

Considering the derived formula for $G(t)$ in (2.11), we need to compute the change of the median abilities due to a change in the threshold value t:

$$\frac{da_L(t)}{dt} = \frac{1}{2}\frac{f(t)}{f(a_L(t))}, \quad \frac{da_H(t)}{dt} = \frac{1}{2}\frac{f(t)}{f(a_H(t))}.$$

Using those derived formulas above in the definition of $G(t)$ (equ. (2.11)) gives us the condition for magnification:

$$G(t) = \frac{1}{2}\left[\frac{f(t)}{f(a_H(t))}\frac{b}{1+ba_H(t)} - \frac{f(t)}{f(a_L(t))}\frac{1}{1+a_L(t)}\right] < 0,$$

and we arrive at the following proposition:

Proposition 2.1. *Under assumption 2.1 and the additional requirement that* $f(0) = f(1) = c$*,* $c \in [0, 1/2)$*, the effect of a change in the relative wage on the skill premium – measured by median wages – through immigration is magnified (compensated) by an endogenous labour-supply*

[12]The median for the respective groups is calculated using the conditional ability distribution: $(1/F(t))\int_0^t f(a)da$ and $(1/(1-F(t)))\int_t^1 f(a)da$.

reaction, iff the relative labour supply before immigration is sufficiently high (low).

Proof. Please consult the appendix. □

The requirement that $f(0) = f(1) = c \in [0, 1/2)$ is not very restrictive because even a boundary weight of $1/2$ is rather implausible. Especially, if one thinks of abilities as some kind of measurable IQ the usual distribution used in IQ studies is the normal distribution with a mean of 100 and a standard deviation of 10 to 15. Applied to our chosen standardisation of abilities between zero and one this would give us an approximate weight of zero for the lower and upper bound of the ability interval.

Next , we analyse the change of the skill premium using the mean as a representative wage. The mean wage of the low and high-skilled group are defined by:

$$E_L(t) = \frac{1}{F(t)} \int_0^t af(a)da \quad \text{and} \quad E_H(t) = \frac{1}{1 - F(t)} \int_t^1 af(a)da.$$

Taking the derivative of the mean wage with respect to the ability threshold t leads to:

$$E_L^{'}(t) = \frac{f(t)}{F(t)}[t - E_L(t)] \quad \text{and} \quad E_H^{'}(t) = \frac{f(t)}{1 - F(t)}[E_H(t) - t].$$

Using the mean and its derivative in the expression for $G(t)$ gives the following condition for magnification:

$$G(t) = \left[\frac{bE_H^{'}(t)}{1 + bE_H(t)} - \frac{E_L^{'}(t)}{1 + E_L(t)} \right] < 0,$$

and we get the following proposition:

Proposition 2.2. *Under assumption 2.1 and the additional requirement that $f(0) = f(1) = c$, $c \in [0, 1/2)$, the effect of a change of the relative wage on the skill premium – measured by mean wages – through immigration is magnified (compensated) by an endogenous labour-supply*

reaction, iff the relative labour supply before immigration is sufficiently high (low).

Proof. Please consult the appendix. □

As propositions 2.1 and 2.2 show there is no qualitative difference in using the median or the mean wage as the representative wage. But as illustrated in figure 2.3, where we simulated the function $G(t)$ for the triangle distribution setting $b = 1.4$, the magnification (compensation) effect is even stronger by using the median.

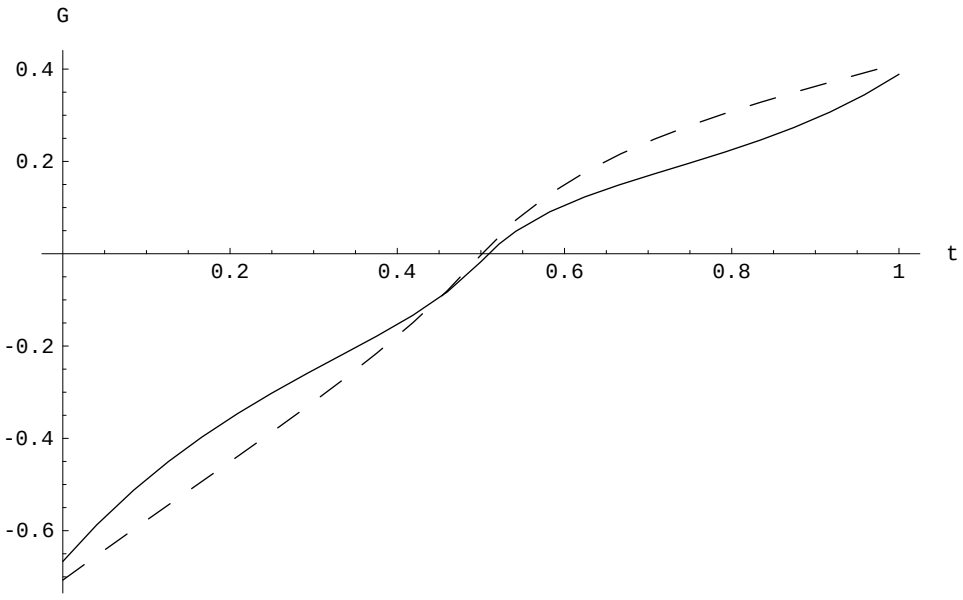

Figure 2.3: The function $G(t)$ assuming a triangle distribution and $b = 1.4$. The dashed line depicts the median and the solid line depicts the mean.

What both propositions indicate is quite surprising. The existing educational level of the economy before immigration is the main cause for magnification or compensation. Hence countries with a high level of education (a small value of t) are very prone to magnification of the rising relative wage. This can be explained as follows: a high degree of educational attainment leaves a rather small group of low-skilled workers compared to the total workforce. An increase of the relative wage adds only a few (compared to the existing high-skilled workers) to the lower ends of the high-skilled income distribution. This leads to nearly no change of the mean/median wage income of the high-skilled

workers. Compared to the existing small group of low-skilled workers, the drain of those few leads to a significant change of the median/mean wage income of the group of low-skilled workers. Both effects add up to an increase of the skill premium.

Sustained immigration can also be a source of a high level of education in the host country. A country like the US with a long tradition of mostly low-skilled immigration will experience an increase of the skill premium. Countries with a small relative supply of high-skilled labour which experience first time immigration are rather likely to observe a decreasing skill premium. As we argue in the next section this result even holds if we replace the assumption of an undistorted labour market by that of a labour market with a binding minimum wage. The binding minimum wage may be the result of union power or fair-wage considerations.

2.3.2 Immigration under rigid wages

In this subsection we analyse the influence of immigration on the measured skill premium with a real minimum wage. By introducing a minimum wage we are aiming at the experiences made in Continental Europe.[13]

Consider a real minimum wage $\overline{w}$ per physical unit of labour, which is binding only for the group of low-skilled workers.[14] Then there exists an ability threshold $\overline{a}(w_L; \overline{w})$ representing the least employable ability:

$$\overline{a}(w_L; \overline{w}) = \{a : \overline{w} = (1 + a)w_L, \overline{w} > w_L\}. \tag{2.12}$$

Any worker with abilities lower than $\overline{a}(w_L; \overline{w})$ will not be employed by firms because the minimum wage income $\bar{w}$ is larger that the marginal productivity of the worker. The

[13]The evolution of the skill premium is rather mixed within Continental Europe: we observe decreasing, constant or slightly rising skill premia (cf. Siebert, 1997).

[14]Two different scenarios are possible: a binding minimum wage before and after immigration or an initially non binding minimum wage which then becomes a binding one after immigration of low-skilled labour. We analyse only the first scenario since the second is just the transition from the flexible wage case to that of a binding minimum wage case.

native unemployment rate resulting from such a binding minimum wage is given by all workers with abilities lower than the threshold value $\overline{a}(w_L; \overline{w})$:

$$U(w_L; \overline{w}) = \int_0^{\overline{a}(w_L;\overline{w})} f(a)da. \tag{2.13}$$

A lower wage rate in efficiency units for low-skilled workers drives the ability threshold $\overline{a}$ up and leaves more low-skilled workers unemployed: $d\overline{a}/dw_L < 0$.

With minimum wage legislation we have to differentiate between the relative labour supply and the employable relative labour. The relative labour supply results from educational decisions of individuals at a given relative wage ω. However, a binding minimum wage leaves all workers $a < \overline{a}$ unemployed. This leads to higher employable relative labour with a binding minimum wage. Both, relative labour supply and the employable labour supply coincide in the case of a non-binding minimum wage. Given our assumptions about the technology, the low-skilled wage rate is a function of the relative labour used in production. Therefore we can define η as the specific relative labour used in production leading to a wage rate of low-skilled w_L which equals the minimum wage:

$$\eta = \left\{ \frac{H}{L} : \frac{\partial Y}{\partial L} = \overline{w} \right\}.$$

We define the employable relative labour including the supply of immigrants of both skill groups as:

$$\frac{H}{L} = \begin{cases} h_I(\omega) & h_I(\omega) \geq \eta \\ \frac{H_I + H(\omega)}{L_I + L(\omega) - U(w_L;\overline{w})} & h_I(\omega) < \eta \end{cases} \tag{2.14}$$

A wage rate w_L higher than the minimum wage does not change the relative labour supply in comparison to the flexible wage case and is still defined by (2.9). Whenever the wage rate for low-skilled labour is smaller than the minimum wage $w_L < \overline{w}$, unemployment increases the employable relative labour supply as represented by the second term.

Figure 2.4 on the following page illustrates the relative labour supply with a minimum wage. The curve LS represents the relative labour supply whereas eLS illustrates the employable relative labour. As the minimum wage binds at the level η the labour

supply curve eLS becomes less elastic. The flexible wage equilibrium at point A depicted in figure 2.4 cannot be supported as a market equilibrium with a minimum wage $\overline{w}$, because all workers with abilities lower than $\overline{a}$ will not be hired due to the minimum wage legislation. The equilibrium prevailing with a binding minimum wage is depicted as point B. The equilibrium relative wage rate will be lower than in the flexible wage case but the employed relative labour is higher. Compared to a country with flexible wages, we observe less education but higher relative employment of high-skilled labour.

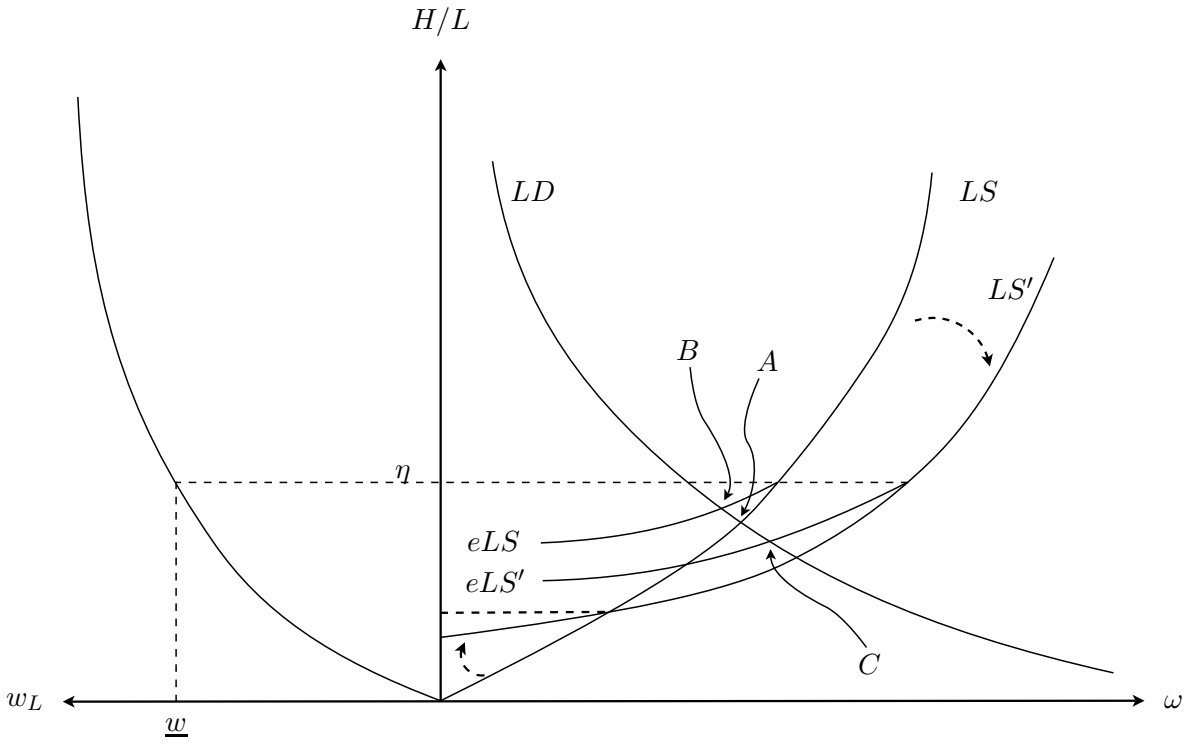

Figure 2.4: The labour market equilibrium with a binding minimum wage $\overline{w}$

When it comes to our measure of the skill premium the wage of the high-skilled group is the same as in the flexible wage case. But with a binding minimum wage we have to revise the representative wage of the low-skilled group because part of the low-skilled are unemployed and without any wage income:

$$m_L = m(w \mid \overline{a} \leq a < t) = 1 + m(a \mid \overline{a} \leq a < t). \tag{2.15}$$

Due to the minimum wage, the wage distribution is truncated at $\overline{w}$ leading to a higher representative wage than under flexible wages. If we use the representative wage in equation (2.15), we end up with the measured skill premium with a binding minimum wage:

$$x = \frac{1 + bm(a \mid a \geq t)}{1 + m(a \mid \overline{a} \leq a < t)}(1 - \lambda)\omega. \tag{2.16}$$

Now the measured wage differential by education does not only depend directly on ω and the educational threshold $t(\omega)$ but also on the minimum wage $\overline{w}$ via the least employable ability $\overline{a}$. Note that there might be significant differences in the skill premium among countries with rigid wages depending on the absolute value of minimum wages. The skill premium under rigid wages can be lower or higher in comparison to the flexible wage case. As the discussion of the change of the skill premium in the flexible wage case has shown the qualitative results are indifferent concerning the use of the median or mean wage. Therefore we limit our discussion of rigid wages to the median wage.

Consider an immigration of low-skilled workers $dH_I/dL_I < (H/L)^*$ into a country with a binding minimum wage, where we assume that a part of the low-skilled immigrants have abilities high enough to be employed in the pre-immigration economy.[15] Figure 2.4 on the facing page illustrates the impact of immigration of low-skilled workers on the labour market.[16] The economy's initial equilibrium point is given by point B. Immigration of low-skilled labour leads to a clockwise rotation of the labour supply curve (from LS to LS'). Therefore the effective labour supply curve also changes its position (from eLS to eLS'). Note that the effective labour supply still becomes less elastic at the specific relative labour level η. The new equilibrium is represented by point C. The equilibrium relative wage $\overline{\omega}^*$ has increased and the relative employment of high-skilled labour has fallen even though more natives invested into training (originating from a lower threshold t). At the same time even more low-skilled workers will be pushed into unemployment due to decreased wages for the low-skilled workers thereby driving up the least employable abilities $\overline{a}$.

When it comes to the change in the measured skill premium, results differ strongly from the flexible wage case. With binding minimum wages the percentage change of the

[15] If all immigrants have abilities below $\overline{a}$ nothing changes in the economy because they are not employable.

[16] The formal derivation can be found in the appendix.

skill premium resulting from a one percent change of the relative wage can be calculated as:

$$\varepsilon^R_{x,\omega} = 1 - \left|t'(\overline{\omega}^*)\right| \overline{\omega}^* G_R(t^*) - \overline{\omega}^* \frac{1}{1+m_L(\overline{a}^*,t^*)} \frac{\partial m_L(\overline{a}^*,t^*)}{\partial \overline{a}} \frac{d\overline{a}}{dw_L} \frac{dw_L}{d\omega}, \tag{2.17}$$

$$\text{with } G_R(t) = \left(\frac{b}{1+bm_H(t)} \frac{\partial m_H(t)}{\partial t} - \frac{1}{1+m_L(\overline{a},t)} \frac{\partial m_L(\overline{a},t)}{\partial t} \right),$$

where R denotes the rigid wage regime. In comparison to the flexible wage case, the change in the skill premium with a binding minimum wage is augmented by a third term. This term measures the change of the representative wage of low-skilled workers due to a change in the least employable abilities $\overline{a}$. This term has a positive sign as long as $dw_L/d\omega < 0$ which is fulfilled given our assumption about the production technology. Therefore the change in the unemployment of low-skilled workers always counteracts the direct wage effect.

To grasp the wage effects of immigration under minimum wage legislation, we will consider two different formulations of a minimum wage: i) $\overline{w} = \gamma w_L$ for some constant $\gamma > 1$ and ii) $\overline{w} = \delta w_H$ for some constant $\delta > 0$. The first formulation captures the idea that the social security system offers an outside option which is for some workers more valuable than their wage income. The second specification can be interpreted as a minimum wage negotiated by a labour union. As to some extent a union tries to reduce the wage dispersion across skill groups by increasing the wage of the lower skill groups (cf. Booth, 1995, pp. 179). We use these simplifying assumptions because we are not interested in modelling the union's decision but in the educational decision of natives.[17] Both specifications represent extremal cases. The first case leads to a constant unemployment rate because $\overline{a}$ is independent of any wage measure, while the second case implies an unemployment threshold $\overline{a}$ proportional to the relative wage ω. However, analysing both cases allows us to draw inferences about any intermediate case.

Starting with formulation i) the third term in (2.17) vanishes because $\frac{d\overline{a}}{dw_L} = 0$ holds and we arrive at the following proposition:

Proposition 2.3. *Under assumption 2.1 and a binding minimum wage given by $\overline{w} = \gamma w_L$ the impact of immigration on the skill premium is more likely to be compensated than under flexible*

[17] Fuest and Thum (2001) model the decision problem of the union but neither the educational decision nor unemployment has been explicitly described.

wages if the educational threshold $t \in [\overline{a}, 1-\overline{a}]$.

Proof. Consider the difference

$$\Delta \equiv G_R(t) - G(t) = 1/\left[f(m_L)\left(1+m_L\right)\right] - 1/\left[f(m_L^R)\left(1+m_L^R\right)\right]$$

where we used the fact that the representative wages of high-skilled workers and its derivatives are the same in both regimes. We only need to show under which circumstances $\Delta > 0$ holds. As $m_L \leq m_L^R$, the sign of Δ depends on the density f evaluated at both median positions. Unimodality and symmetry guarantee that $f(m_L) \leq f(m_L^R)$ as long as $t \in [\overline{a}, 1-\overline{a}]$. □

The claim of proposition 2.3 is that the chance of compensation increases with the existence of a minimum wage. This confirms the intuition of wage rigidity, which concludes that the change of wage inequality is dampened compared to flexible wages. However, the basic mechanism of compensation and magnification which we sketched within a flexible wage framework still exists. Figure 2.5 on the next page illustrates the difference between the flexible and the rigid wage regime. Obviously the intersection of $G(t)$ with the t axis moves to the left, leaving a larger interval for magnification. However, the possibility of magnification is still present. Considering case ii) means that the third term in (2.17) is positive which leaves the results derived in proposition 2.3 unaltered.

Thus, the main result of our analysis of immigration within the framework of rigid wages is that the mechanism of compensation and magnification is robust. This result differs to the conventional wisdom: under rigid wages we cannot exclude the possibility of magnification of the direct wage effect. More precisely, there is only a higher chance of compensation to arise. Labour market rigidities are likely to generate higher unemployment rates and as our analysis indicates *either* increasing or decreasing skill premia. But the differences in the development of the unemployment rate and the skill premium between the US and Continental Europe (the often cited two sides of the same coin) do not seem to be as clear cut as the literature may suggest.[18] Depending on the structural

[18] See Nickell et al. (2005) for empirical support of doubts on this conventional wisdom.

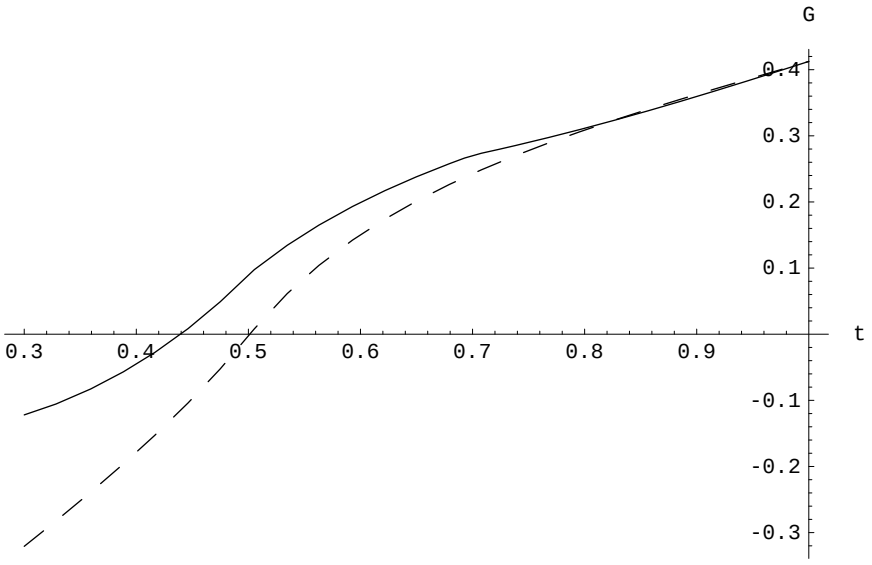

Figure 2.5: The function $G(t)$ assuming a triangle distribution and $b = 1.4$. The dashed line depicts the flexible wage case and the solid line depicts the minimum wage case assuming a fixed unemployment threshold $\overline{a} = 0.3$.

parameters of the economy low-skilled immigration can lead to a strong increase of the skill premium with flexible and rigid wages alike.

2.4 Conclusion

We argued that immigration generates two effects: a direct wage effect but also a compositional effect which influences the decision of heterogeneous agents to invest in education. Taking this compositional effect into account, we can show that under reasonable conditions the direct wage effect is either magnified or compensated depending on the initial relative labour employed in production. The magnification results from the revised human capital investment decision of the native population. A higher fraction of natives invests in education making the group of high-skilled more heterogeneous and at the same time the group of low-skilled more homogeneous.

Within this model, the existing relative labour supply of a country is the relevant determinant for magnification or compensation of the skill premium. Furthermore the results of the model are robust to changing labour market institutions. These two findings are partially in contrast to the existing literature. We can show that the magnification

effect on the skill premium in the flexible wage case which corresponds to the increasing skill premia in the US or the UK. But we cannot exclude the possibility of magnification of the skill premium in the case of rigid wages considering immigration of low-skilled workers. Labour market rigidities may therefore lead to increasing skill premia.

Furthermore there is an influence through the length of education λ because it influences t. Countries with a higher λ (Germany could serve as an example) are prone to compensation and countries with a lower λ are prone to magnification.

The analysis also provides a possible explanation of the mixed results of empirical studies on the labour market impact of immigration. A part of the empirical studies come to the conclusion that immigration has none or only a relatively small negative impact on the wages of native workers[19], whereas others studies suggest a stronger effect of immigration.[20] These puzzling results may come from the revised educational decision of natives which depend on immigration of low-skilled workers and the structural parameters of the economy. Borjas (1994) presents evidence that there was a stronger attainment of higher education of US natives in the respective period. We see two possibilities for future research. First, there could be a possible empirical analysis of the influence of immigration on educational attainment. This channel could serve as a further explanation of the differing results between the analysis of local and national labour markets (compared to the proposed explanation of internal migration decisions of Borjas (2005)). Second, it might be important to introduce intergenerational effects. Card (2005), for example, describes the assimilation success of the children of immigrants through education. These children have higher education as the comparable native children.

[19]See Card (2001) among others for the US as an example for flexible wages and Pischke and Velling (1997) for Germany as an example of unionised wages.

[20]Borjas (2003) finds that immigration has an significant negative impact on the wage earnings of the natives: a ten percent increase in immigration reduces the native wage by three to four percent.

2.A Appendix

2.A.1 Comparative statics of ω^* under minimum wages

Next, we derive the comparative statics of the labour market for binding and nonbinding minimum wage legislation. Labour market equilibrium $(\omega^*, (H/L)^*)$ with immigration is given by:

$$\left(\frac{H}{L}\right)^*_{LD} = g(\omega^*) \tag{A2.1}$$

$$\left(\frac{H}{L}\right)^*_{LS} = \frac{H_I + (1-\lambda)\int_{t(\omega^*)}^{1}(1+ba)f(a)da}{L_I + \int_{\overline{a}(w_L^*;\overline{w})}^{t(\omega^*)}(1+a)f(a)da} \tag{A2.2}$$

$$\overline{a}(w_L^*;\overline{w}) = \begin{cases} \frac{\overline{w}-w_L^*}{w_L^*} & \text{if } \overline{w} > w_L^* \\ 0 & \text{otherwise} \end{cases} \tag{A2.3}$$

$$w_L^* = f((H/L)^*) - f'((H/L)^*)(H/L)^* \tag{A2.4}$$

in which the first and second equation constitute the labour supply and demand which are equal in equilibrium $(H/L)_{LD} = (H/L)_{LS}$. The third and the fourth equation give the lowest employable ability at the given minimum wage $\overline{w}$ and the resulting low-skilled wage per efficiency units at the equilibrium ratio of high to low-skilled labour. Since we are interested in the equilibrium change of the skill premium and of the relative physical labour supply through immigration, we take the total differential of labour demand and supply:

$$d\left(\frac{H}{L}\right)^*_{LD} = g'(\omega^*)d\omega^* \tag{A2.5}$$

$$d\left(\frac{H}{L}\right)^*_{LS} = \frac{\partial\,(H/L)_{LS}}{\partial\omega}d\omega^* + \frac{\partial\,(H/L)_{LS}}{\partial\overline{a}}\frac{d\overline{a}}{dw_L}dw_L^* + \frac{\partial\,(H/L)_{LS}}{\partial H_I}dH_I + \frac{\partial(H/L)_{LS}}{\partial L_I}dL_I \tag{A2.6}$$

$$dw_L^* = -f''((H/L)^*)(H/L)^* d\left(\frac{H}{L}\right)^* \tag{A2.7}$$

Since the equilibrium requires equality of the labour supply and demand, the comparative statics of the equilibrium requires: $d(H/L)^* = d(H/L)_{LS} = d(H/L)_{LD}$. The

term dw_L^* in (A2.6) can be substituted with (A2.7). After substitution of $d(H/L)^*$ with the demand relation (A2.5) we arrive at:

$$\left(1 - \frac{\partial\left(H/L\right)_{LS}}{\partial\overline{a}}\frac{d\overline{a}}{dw_L}\left|f''((H/L)^*)\right|(H/L)^*\right)g'(\omega^*)d\omega^* = \frac{\partial\left(H/L\right)_{LS}}{\partial\omega}d\omega^* + \frac{\partial\left(H/L\right)_{LS}}{\partial H_I}dH_I + \frac{\partial(H/L)_{LS}}{\partial L_I}dL_I \quad \text{(A2.8)}$$

We use the results from the text for the partial effects of immigration of low and high-skilled labour to solve for $d\omega^*$:

$$d\omega^* = \frac{\frac{1}{L_I + \int_{\overline{a}(w_L^*;\overline{w})}^{t(\omega^*)}(1+a)f(a)da}\left(dH_I - \left(\frac{H}{L}\right)^* dL_I\right)}{\left(1 - \frac{\partial(H/L)_{LS}}{\partial\overline{a}}\frac{d\overline{a}}{dw_L}\left|f''((H/L)^*)\right|(H/L)^*\right)g'(\omega^*) - \frac{\partial(H/L)_{LS}}{\partial\omega}} \gtreqless 0 \quad \text{if } \frac{dH_I}{dL_I} \gtreqless \left(\frac{H}{L}\right)^* \quad \text{(A2.9)}$$

The relative wage change coincides with the flexible wage case derived in the text by setting $\partial\left(H/L\right)_S/\partial\overline{a}$ equal to zero. All results from the flexible wage regime apply because there is no principal difference between the minimum wage regime and the flexible wage regime. The main difference is that with binding minimum wage for the group of low-skilled workers, there exists no competitive relative labour supply. But there exists a supply relation which already incorporates demand effects.

2.A.2 Proof of Proposition 2.1

First, we proof that the limit of the function $G(t)$ at the lower (upper) bound is always negative (positive): $\lim_{t\to 0} G(t) < 0, \lim_{t\to 1} G(t) > 0$. Then we show that $G(t)$ has at most one root. Taking the limit of $G(t)$ at the lower and upper bound of the ability interval gives the following expressions:

$$\lim_{t\to 0} G(t) = \frac{1}{2}\left(\frac{f(0)}{f(a_H(0))}\frac{b}{1+ba_H(0)} - \frac{f(0)}{f(a_L(0))}\frac{1}{1+a_L(0)}\right) = \frac{1}{2}\left(\frac{c}{f(1/2)}\frac{b}{1+b/2} - 1\right) \quad \text{(A2.10)}$$

$$\lim_{t\to 1} G(t) = \frac{1}{2}\left(\frac{f(1)}{f(a_H(1))}\frac{b}{1+ba_H(1)} - \frac{f(1)}{f(a_L(1))}\frac{1}{1+a_L(1)}\right) = \frac{1}{2}\left(\frac{b}{1+b} - \frac{c}{f(1/2)}\frac{2}{3}\right) \quad \text{(A2.11)}$$

Because of $f(1/2) > 1$, the term $c/f(1/2) \in [0, c)$ and therefore $c < 1/2$ is a necessary and sufficient condition for $\lim_{t\to 0} G(t) < 0$ and $\lim_{t\to 1} G(t) > 0$ to hold independent

of the value of b. Note that a $b \ll \infty$ also allows for $c > 1/2$. To get the unambiguous result, that only magnification occurs with relative labour sufficiently high (t small), we need to rule out more than one root. We define the root of $G(t)$ as the value t^* leading to: $G(t^*) = 0$. Simplifying the function of $G(t)$ leads to:

$$\widetilde{G}(t) = \frac{f(a_L(t))}{f(a_H(t))} - \frac{1 + ba_H(t)}{b\,(1 + a_L(t))}.$$

The sign of $G(t)$ and $\widetilde{G}(t)$ are the same, therefore it is sufficient to show that $\widetilde{G}(t)$ has at most one root because this result will also apply to $G(t)$. Taking the derivative of $\widetilde{G}(t)$ gives us:

$$\widetilde{G}'(t) = \frac{df(a_L(t))/f(a_H(t))}{dt} - \frac{d\,(1 + ba_H(t))\,/b\,(1 + a_L(t))}{dt}. \tag{A2.12}$$

The first term in (A2.12) is positive because we assumed single peakness and symmetry of the distribution. The second term can be further calculated as:

$$\frac{d\,(1 + ba_H(t))\,/b\,(1 + a_L(t))}{dt} = \frac{f(t)}{2\,(1 + a_L(t))\,f(a_L(t))}\left(\frac{f(a_L(t))}{f(a_H(t))} - \frac{1 + ba_H(t)}{b\,(1 + a_L(t))}\right),$$

implying that the sign of the second term in (A2.12) is given by:

$$sgn\left(\frac{d\,(1 + ba_H(t))\,/b\,(1 + a_L(t))}{dt}\right) = sgn\left(\widetilde{G}(t)\right).$$

As a consequence we get that whenever $\widetilde{G}(t) \leq 0$ holds, we know that $\widetilde{G}'(t) > 0$ and therefore the function $\widetilde{G}(t)$ – and also $G(t)$ – can have at most one root. Together with the result of $\lim_{t\to 0} G(t) < 0$ and $\lim_{t\to 1} G(t) > 0$, we establish the result that $G(t)$ has one unique root. Furthermore we have proofed for t sufficiently low that magnification occurs ($G(t) < 0$).

2.A.3 Proof of Proposition 2.2

We calculate the limit of the first derivatives of the mean wage for the respective educational groups with the following properties of the truncated mean:

$$\lim_{t\to 0} E_L^{'}(t) = \lim_{t\to 1} E_H^{'}(t),$$

$$\lim_{t\to 1} E_L^{'}(t) = \lim_{t\to 0} E_H^{'}(t).$$

First, we derive $\lim_{t\to 0} E_L^{'}(t)$:

$$\lim_{t\to 0} E_L^{'}(t) = \lim_{t\to 0} t\frac{f(t)}{F(t)} - \lim_{t\to 0} \frac{f(t)}{F(t)^2} \int_0^t af(a)da. \tag{A2.13}$$

Applying L'Hôpital's rule on the first term of the equation (A2.13) gives:

$$\lim_{t\to 0} t\frac{f(t)}{F(t)} = \lim_{t\to 0} \frac{f(t) + tf^{'}(t)}{f(t)}.$$

Applying L'Hôpital's rule a second time for $c = 0$:

$$\lim_{t\to 0} t\frac{f(t)}{F(t)} = \lim_{t\to 0} \frac{f(t) + tf^{'}(t)}{f(t)} = \lim_{t\to 0} \frac{2f^{'}(t) + tf^{''}(t)}{f^{'}(t)} = 2.$$

We arrive then at the following result for the first term:

$$\lim_{t\to 0} t\frac{f(t)}{F(t)} = \begin{cases} 2 & \text{for } c = 0 \\ 1 & \text{for } c > 0 \end{cases}. \tag{A2.14}$$

We are now looking at the second term of equation (A2.13):

$$\lim_{t\to 0} \frac{f(t)}{F(t)^2} \int_0^t af(a)da = \lim_{t\to 0} \frac{f^{'}(t)\int_0^t af(a)da}{2F(t)f(t)} + \frac{1}{2}\lim_{t\to 0} t\frac{f(t)}{F(t)}. \tag{A2.15}$$

The second term of equation (A2.15) has the same limit as equation (A2.14) but the first term is still undecidable $(c = 0)$.

Applying l'Hôpital's rule twice and with $t = 0$, $f(t) = 0$, $F(t) = 0$, we get the following expression:

$$\lim_{t\to 0} \frac{2f^{'}(t)^2}{6f^{'}(t)^2} = \frac{1}{3}.$$

The limit of the second term of (A2.13) is therefore:

$$\lim_{t\to 0} \frac{f(t)}{F(t)^2} \int_0^t a f(a) da = \begin{cases} \frac{4}{3} & \text{for } c = 0 \\ \frac{1}{2} & \text{for } c > 0 \end{cases} . \tag{A2.16}$$

We can derive $\lim_{t\to 0} E_L^{'}(t)$ from the equations (A2.13) and (A2.16):

$$\lim_{t\to 0} E_L^{'}(t) = \begin{cases} \frac{2}{3} & \text{for } c = 0 \\ \frac{1}{2} & \text{for } c > 0 \end{cases} , \tag{A2.17}$$

and with the relation $\lim_{t\to 1} E_L^{'}(t) = \lim_{t\to 1} \frac{f(t)}{F(t)}(t - E_L)$, we get:

$$\lim_{t\to 1} E_L^{'}(t) = \begin{cases} 0 & \text{for } c = 0 \\ \frac{c}{2} & \text{for } c > 0 \end{cases} .$$

Taking again the limit of $G(t)$ at the lower and upper bound of the ability interval gives the following expressions:

$$\lim_{t\to 0} G(t) = \left[\frac{bE_H^{'}(0)}{1 + bE_H(0)} - \frac{E_L^{'}(0)}{1 + E_L(0)} \right] = \left[\frac{b}{1 + b/2} \frac{c}{2} - E_L^{'}(0) \right],$$

$$\lim_{t\to 1} G(t) = \left[\frac{bE_H^{'}(1)}{1 + bE_H(1)} - \frac{E_L^{'}(1)}{1 + E_L(1)} \right] = \left[\frac{b}{1 + b} E_H^{'}(1) - \frac{c}{3} \right].$$

As we have shown in equation (A2.17), $E^{'}(0) = E^{'}(1)$ have the value $2/3$ for $c = 0$ and $1/2$ for $c > 0$. Therefore, we conclude that the limit of the function $G(t)$ at the lower (upper) bound is always negative (positive): $\lim_{t\to 0} G(t) < 0, \lim_{t\to 1} G(t) > 0$ for $c \in [0, 1/2)$. Furthermore this is a necessary and sufficient condition for $\lim_{t\to 0} G(t) < 0$ and $\lim_{t\to 1} G(t) > 0$ to hold independent of the value of b.

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CHAPTER 3

Immigration policy, equilibrium unemployment, and underinvestment in human-capital

3.1 Introduction

The impact of immigration on the labour market prospects of natives has been subject of public and academic discussions. Most of the discussion is about the influence of actual immigration flows on native wages and employment prospects and thus how to choose immigration policy optimally. In fact, in some countries (e.g., Canada, Australia) immigration policy explicitly aims at augmenting domestic labour supply of skilled workers by a certain quality (in terms of skills) and volume to support the development of the national economy. Other countries like Germany, the UK and the US, discuss about reforming immigration policy in favour of a more selective immigration in terms of skills. Furthermore, in the host country's economy, immigrants are not distributed uniformly over their labour markets. Typically, immigrants are concentrated, both locally (e.g., 80 to 90 per cent of the population of London and Miami are foreign-born) and in certain sectors of the economy (in the US, Mexicans work mainly in agriculture and in the UK most of the Irish or Eastern European immigrants work in construction). Thus, we focus on the impact of immigration on natives on local labour markets and on sectors with high immigration rates.[1]

Still, most of the public and academic discussion concentrates only on the direct effect of immigration on wages and employment through a change in labour supply. In contrast, we explicitly include the change of incentives to educate as an additional channel by which immigration may influence the labour market outcome of natives and solve underinvestment in human capital. Considering this further channel, our subsequent analysis shows that an immigration policy favouring high-skilled immigration is able to foster human capital acquisition of natives and we can also show that this kind of policy is Pareto-improving. Even a Pareto-optimal investment level can be reached if domestic education is appropriately subsidised at the same time. Thus, our analysis gives a theoretical underpinning for a skill-selective immigration policy. Thereby our models contains the following characteristics of native labour markets and of the immigrant population.

Most of the local labour markets are characterised by frictional unemployment – even in more or less competitive markets like the US and UK. This simultaneous existence of vacancies and unemployment can only be explained by search-theoretic approaches

[1]See Bartel (1989); Portes and Rumbaut (1996); Dustmann et al. (2003) for the local concentration of immigrants and see Dustmann et al. (2003); Chiswick and Sullivan (2005) for the sectoral concentration of immigrants in the US and UK.

(cf. Pissarides, 2000; Layard et al., 2005). Thus, we apply a search-theoretic model with endogenous human capital investment which allows for frictional unemployment. A further feature of this approach is that it features underinvestment in human capital (cf. Acemoglu, 1996; Moen, 1998; Sato and Sugiura, 2003).

Next to the characteristics of the host country's labour markets, our approach accounts also for some characteristics of the immigrant population in the host country. Immigrants typically return to their home country with a positive probability.[2] Introducing a positive probability of returning home leads to a higher job destruction rate (shorter employment spells) for immigrants than for natives. As a partial result, our model can explain two stylised facts of economies with immigration: first, immigrants with the same human capital endowment earn lower wages than natives. Second, the unemployment rate of immigrants is higher than the unemployment rate of natives. Immigrants are therefore discriminated ex post against natives because of their higher probability to leave the match.[3] This has to be distinguished from ex ante discrimination because in our model firms do not offer vacancies which are specific to immigrants or natives. However, the introduction of ex ante discrimination would not change our results because immigrants would earn even lower wages than natives.

This paper is related to a number of contributions in the literature. First, some articles have analysed migration in a search theoretic context. Ortega (2000) analyses migration patterns in a two country model and the impact of migration on employment and wages in the host and origin country. Sasaki (2007) combines the search framework with a specific-factors models in a two country setting and concentrates also on migration patterns. We differ from these papers in the consideration of the impact of immigration on human capital investments and its impact on wages and employment in the host country.

The concentration on the host country gives us the opportunity to compare our results with results from previous studies on immigration, human capital and labour market frictions. Schmidt et al. (1994) show that low-skilled immigration might be beneficial for the host country if immigrants decrease the wage claim of a monopoly union. Fuest and Thum (2001) argue in an efficient bargaining model that low-skilled immigration

[2] For a detailed theoretical and empirical discussion on return migration see Dustmann (2003). Mueller (2003) also introduces return migration in an efficiency-wage model.

[3] The kind of discrimination in our model is different to the discrimination in the model of Mueller (2003) because we have explicit wage differences between natives and immigrants on the same type of job.

might increase native educational attainment and thus be beneficial for the host country. Our approach differs significantly in the way we model labour market institutions. In contrast to the former approach, unemployment is the result of search frictions and applies therefore to any economy whereas monopoly unions are not a main feature of the Anglo-Saxon labour markets. The latter approach includes no unemployment at all. Moreover, our approach of the labour market contrasts sharply with the existing literature on immigration, because the major focus of the existing literature has been mostly on stocks and its composition in a static context (Borjas, 1995, 1999).

Our main result is that an immigration policy aiming at well educated immigrants increases incentives to create more vacancies thus rising the wage paid by firms.[4] Therefore high-skilled immigration leads to rising educational attainment of natives. This is in contrast to the existing literature of immigration and human capital which shows that low-skilled immigration may rise educational attainment of natives (cf. Fuest and Thum, 2001). Therefore, our result supports a rather skill selective immigration policy (e.g., Australia and Canada) which is opposite to the actual immigration policies of most European countries. Furthermore, choosing appropriate education subsidies, the distortion generating underinvestment in human capital can be removed such that a Pareto-optimal investment level is reached. As an additional result, we demonstrate that either the appropriate number of immigrants (the flows) or the appropriate educational attainment (its characteristics in terms of human capital stocks) of immigrants can have the same effect as unemployment benefits proposed by Sato and Sugiura (2003).[5]

The remainder of the paper is structured as follows: in section 3.2 we present the basic structure of the model. In section 3.3 we derive both the solution of the individual human capital investment decision problem and the market equilibrium. In section 3.4 we analyse the efficiency of the market outcome and discuss different immigration policies which are appropriate to overcome the underinvestment. In section 3.5, we calibrate the model for the US economy. Section 3.6 presents an extension of the basic model by including segemented labour markets of different skill groups. Section 3.7 concludes.

[4]Lewis (2003, 2004) shows first empirical evidence for the increasing number of vacancies depending on the existing labour supply.

[5]We concentrate on the impact of immigration on the labour market outcome of natives. There is a large literature which analysis the consequences of immigration on the welfare system and/or on the collective decision making (cf. Ortega, 2005; Kemnitz, 2006).

3.2 Basic model

3.2.1 Households

We develop an equilibrium matching model of the Diamond-Mortensen-Pissarides type (cf. Pissarides, 2000). The economy is populated by a mass one of identical risk-neutral native workers $N = 1$ and foreign workers (immigrants) $I \geq 0$ adding to a total population $L = 1 + I$.[6] All individuals and firms discount future payments at a common rate ρ. Native workers enter and exit the labour market at a constant rate $\delta_N > 0$ such that the number of native workers is constant over time.[7] The number of *potential* immigrants is normalised to one which simplifies the exposition of the model. Immigrants enter a country's labour market at rate $\mu > 0$ and leave the labour market due to retirement at rate $\delta_N > 0$ or migration back to the home country at rate $r > 0$. The total exit rate of immigrants adds to $\delta_I = \delta_N + r$.[8] The net flow of immigrants can therefore be calculated as $\dot{I} = \mu - \delta_I I$. The steady state number of immigrants ($\dot{I} = 0$) in the host country is then $I = \mu/\delta_I$. To simplify the exposition of the model we denote the immigrants share in total population by $\eta_L = I/(1 + I) = \mu/(\delta_I + \mu)$.

Both native and immigrant workers start their working life in the unemployment pool. Before entering the unemployment pool, native workers have to decide about their human capital investment $z_N > 0$. Once taken, the educational decision is irreversible. The cost per unit of human capital amounts to c, and the total cost of education cz_N will be borne by workers.

Immigrants entering the labour market are assumed to be endowed with human capital z_I which they already acquired in their home country. We assume that there exists no principal difference between the quality of human capital of natives and immigrants.[9] The acquired human capital can be used by any firm meaning that firms make no differences between an immigrant and a native worker.[10] The difference of endowments of

[6] Throughout the paper subscript N denotes natives and subscript I denotes immigrants.

[7] The rate δ_N is the birth and retirement rate in the economy.

[8] In most industrialised countries we observe a large return migration which justifies our assumption of $r > 0$. In our model the return rate r is assumed to be exogenous, although, the decision to return to the home country is taken by the immigrant.

[9] At least at the beginning, the human capital quality of immigrants will differ from the human capital of natives (e.g. by language proficiency), but including this assimilation process would only strengthen the results of the model.

[10] See Bowlus and Eckstein (2002) or Black (1995) for discrimination in search models.

human capital between natives and immigrants will only be reflected in the wages paid by firms.

Natives and immigrants can be in two different states: they are either working or searching for a job. We abstract from on-the-job search.

3.2.2 Matching

We denote the number of unemployed workers by u and the number of vacancies searching for a worker by v. The ratio $\theta = v/u$ is called labour market tightness. The random process by which vacancies and unemployed workers find each other is represented by a matching function $m(u, v) > 0$, with $u, v > 0$. The matching function denotes the number of matched vacancies and workers per unit of time.[11] The application arrival rate for vacant jobs $q(\theta)$ can then be written as $q(\theta) = m(u, v)/v = m(1/\theta, 1)$, with $q'(\theta) < 0$ and $\lim_{\theta\to 0} q(\theta) = \infty$, $\lim_{\theta\to\infty} q(\theta) = 0$. An unemployed worker meets a vacant job at the rate $p(\theta) = m(u, v)/u = \theta q(\theta)$, with $p'(\theta) > 0$, $\lim_{\theta\to 0} p(\theta) = 0$ and $\lim_{\theta\to\infty} p(\theta) = \infty$. Native workers and immigrants meet a vacant job at the same rate. Note that potential firms cannot directly search either a native worker or an immigrant worker. Whether it is a native worker or an immigrant will be revealed when a firm and a worker meet.

The Beveridge curve

The flow equation of umployment $\dot{u}$ characterising the labour market is the difference between the inflows into unemployment and the outflows from unemployment. With both natives and immigrants being in the pool of unemployed workers, we have two different flow equations for each group. Inflows into unemployment occur if a job is closed or new workers enter the labour market. Any filled job can be destroyed due to two different reasons: either the job is hit by an exogenous negative productivity shock at rate s, or the job is closed because the employee leaves the labour market completely

[11] The matching function $m(u, v)$ is assumed to be twice continuously differentiable, homogeneous of degree one and exhibits the following properties: $m(0, v) = m(u, 0) = 0$, $\partial m/\partial u$, $\partial m/\partial v > 0$, $\partial^2 m/\partial u^2, \partial^2 m/\partial v^2 < 0$ and $\partial^2 m/\partial u \partial v > 0$.

with rate δ_i, $i = I, N$. Note that only the former increases the number of unemployed. The respective dynamics of unemployment are given by:

$$\dot{u}_N = \delta_N + s(1 - u_N) - p(\theta)u_N - \delta_N u_N, \tag{3.1}$$

$$\dot{u}_I = \mu + s(I - u_I) - p(\theta)u_I - \delta_I u_I. \tag{3.2}$$

In the steady state $\dot{u}_i = 0$ ($i = I, N$), we obtain the following *number* of unemployed native[12] and immigrant workers:

$$u_N = \frac{\delta_N + s}{s + p(\theta) + \delta_N}, \quad u_I = \frac{\mu}{\delta_I}\frac{\delta_I + s}{s + p(\theta) + \delta_I}, \tag{3.3}$$

with $u_N \in [0, 1]$ and $u_I \in [0, \mu/\delta_I]$. The aggregated Beveridge curve of the economy is then given by the sum of unemployed natives and immigrants:

$$u = \frac{\delta_N + s}{s + p(\theta) + \delta_N} + \frac{\mu}{\delta_I}\frac{\delta_I + s}{s + p(\theta) + \delta_I}. \tag{3.4}$$

Comparing the unemployment *rates* of natives and immigrants we arrive at the following result:

Corollary 3.1. *The unemployment rate of immigrants is always higher than the unemployment rate of natives:* $u_N < u_I/I$.

Proof. Using equation (3.3) together with the definition of the unemployment rate it follows that $u_N < u_I/I$. □

The immigrants' share in unemployment is always greater than the immigrants share in total population: $\eta_U(\theta) = u_I/(u_I + u_N) > I/(1 + I) = \eta_L(\theta)$. Therefore our model features a well documented fact of labour markets in most industrialised countries (cf. Hatton and Williamson, 2005, p. 325, 15.3).[13]

[12] Because the number of natives is standardised to one, the number of unemployed natives is also the unemployment rate of natives.

[13] Interestingly, most of the empirical literature concentrates on the explanation of wage differentials between natives and immigrants. There are very few papers analysing immigrants incidence of unemployment (cf. McDonald and Worswick (1997) for Canada, Arai and Vilhelmsson (2004) for Sweden).

Match formation and wage setting

Let U_i and W_i, $(i = I, N)$, be the expected present value of unemployment and employment, respectively. The flow value (asset value) of unemployment is given by:

$$\rho U_i = b + p(\theta)(W_i - U_i) - \delta_i U_i, \quad i = I, N. \tag{3.5}$$

With b denoting the instantaneous value of leisure b, an unemployed worker will meet a vacant job at rate $p(\theta)$, thereby swapping the value of unemployment U_i with the value of employment W_i. At rate δ_i an unemployed worker is expected to leave the labour market and therefore loses the value of unemployment U_i.[14]

By the same argument the flow value of an employed worker can be written as:

$$\rho W_i = w_i + s(U_i - W_i) - \delta_i W_i, \quad i = I, N. \tag{3.6}$$

While employed, a worker receives the wage w_i. The job is expected to be closed at rate s and the worker enters the unemployment pool. Additionally, a job is randomly closed according to the retirement rate δ_i.

We now look at the expected present value of firms which are either producing or searching for a worker. A firm searching for an applicant incurs search cost $k > 0$ at each instant of time. Note that a job can either be filled with a native worker or an immigrant worker. As mentioned before, apart from the differing retirement rates, the only possible difference between both types of workers is the endowment with human capital z_i.

The output of a job-worker pair is generated according to a general production function $f : \mathbb{R}^+ \to \mathbb{R}^+$, with human capital z being the only input in production. The production function has the following properties: $f'(z) > 0$, $f''(z) < 0$, $\lim_{z\to 0} f'(z) = \infty$ and $\lim_{z\to\infty} f'(z) = 0$. Furthermore, we assume that for any $z \geq 0$ the value of output is strictly greater than the value of leisure b: $f(z) > b$.[15]

[14]For simplicity we assume that the value of returning to the home country is zero for immigrants . In any case, the value of returning home should be smaller than the value of unemployment.

[15]Without this requirement a situation can arise where no individual chooses to educate and work.

Let V and J_i be the expected present value of a vacant job and a filled job, respectively. The flow value of a producing firm with worker is given by:

$$\rho J_i = f(z_i) - w_i + (s + \delta_i)(V - J_i), \quad i = I, N.$$

The flow value consists of the flow profits of a match $f(z_i) - w_i$ and the potential loss caused by either the destruction of the job (with rate s) or the retirement of the respective worker (with rate δ_i).

For the derivation of the flow value of a vacancy ρV it is important that ex ante a firm does not know whether it will produce with a native worker or an immigrant worker. The share of unemployed immigrants in the pool of unemployed workers $\eta_U(\theta)$ also reflects the conditional probability of meeting an immigrant job searcher. The effective rate of meeting an unemployed immigrant is $q(\theta)\eta_U(\theta)$ while the effective rate of meeting an unemployed natives is given by $q(\theta)\left(1 - \eta_U(\theta)\right)$. We assume that the effective rate for any group is negatively correlated with labour market tightness θ such that $dq(\theta)(1 - \eta_U(\theta))/d\theta < 0$ and $dq(\theta)\eta_U(\theta)/d\theta < 0$.[16] Any firm offering a vacant job considers the expected present value of a filled job $J^e = \eta_U J_I + (1 - \eta_U)J_N$.[17] The flow value of a vacant job can then be written as:

$$\rho V = -k + q(\theta)(J^e - V).$$

It consists of the flow costs of searching k and the potential gain from a change from a vacant to a productive job $(J^e - V)$.

Free entry of firms generates an asset value of a vacancy of zero: $V_i = 0$. Thus we can calculate the job creation condition of firms as:

$$J^e = \frac{k}{q(\theta)}. \tag{3.7}$$

Free entry leads to an expected present value of a filled job J^e which is equal to the expected costs of finding a worker. We also get the following expression for a filled job

[16]This assumption ensures that the composition effect in the pool of unemployed cannot dominate the effect of an increased labour market tightness. Otherwise, an increase in labour market tightness might decrease the effective rate of meeting an unemployed immigrant while at the same time increasing the effective rate of meeting an unemployed native.

[17]For notational convenience we drop the functional argument θ in $\eta_U(\theta)$ when this causes no confusion.

of type i:

$$J_i = \frac{f(z_i) - w_i}{\rho + \delta_i + s}, \quad i = I, N. \tag{3.8}$$

We assume that wages are negotiated between a matched worker-firm pair according to Nash-bargaining. This means that the wage for worker type i solves the following optimisation problem:

$$w_i = \arg\max \left(W_i(w_i) - U_i\right)^{\beta} \left(J(w_i) - V\right)^{1-\beta}, \quad i = I, N \tag{3.9}$$

where β can be interpreted as the bargaining power of workers.[18] The wage setting function for each type of worker is given by:[19]

$$w_i = \beta f(z_i) + (1-\beta)\frac{b(\rho + \delta_i + s) + p(\theta)\beta f(z_i)}{\rho + \delta_i + s + p(\theta)\beta}, \quad i = I, N. \tag{3.10}$$

Comparing both the wage of natives and immigrants yields the following result:

Corollary 3.2. *Immigrant workers with human capital $z_I \leq z_N$ always earn a lower wage $w_I < w_N$ compared to a native worker.*

Proof. Taking the total differential of the native wage equation we get:

$$dw_N = -\frac{(1-\beta)\beta p(\theta)\left(f(z_N) - b\right)}{\left(\rho + \delta_N + s + p(\theta)\beta\right)^2} d\delta_N + \frac{(1-\beta)\beta p(\theta) f'(z_N)}{\rho + \delta_N + s + p(\theta)\beta} dz_N < 0$$

Evaluating the total differential at $d\delta_N = r$ and $dz_N \leq 0$ completes the proof. □

This result reflects the fact that immigrants have a higher risk of leaving the host countries' labour market. A higher risk of closing a productive job translates into a lower average job duration reducing the potential surplus of the job. Therefore the wage rate, a share of the total surplus, has to be smaller to compensate for this lower duration.[20]

[18] By using this formulation we assume that there is no difference in the bargaining power of natives and immigrants. Presumably the bargaining power of immigrants is lower compared to natives at the beginning of their working life in the host country and the same in the long run. However, taking this into account would not alter the results of the model qualitatively.

[19] The derivation of (3.10) can be found in the appendix.

[20] There is a huge empirical literature analysing the evident wage differential between natives and immigrants: cf. Borjas (1999).

For future reference it will be convenient to derive closed form solutions for U_i and J_i. Together with the wage setting function we derive the expected present value of unemployment in terms of human capital z_i and labour market tightness θ:

$$U_i = \frac{b(\rho + \delta_i + s) + p(\theta)\beta f(z_i)}{(\rho + \delta_i)(\rho + \delta_i + s + p(\theta)\beta)} \quad i = I, N. \tag{3.11}$$

U_i is a weighted average of the value of unemployment b and the share β of the output $f(z_i)$. Note that z_N is endogenous and will be chosen by natives. Using the expression for the wage rate w_i together with the definition of the expected value of a filled job (3.8) of type i yields:

$$J_i = \frac{(1-\beta)(f(z_i) - b)}{\rho + \delta_i + s + \beta p(\theta)} \quad i = I, N. \tag{3.12}$$

This expression can then be used in the free entry condition (3.7) to yield the firms' job creation curve (JCC):

$$\eta_U \frac{q(\theta)(1-\beta)(f(z_I) - b)}{\rho + \delta_I + s + \beta p(\theta)} + (1 - \eta_U) \frac{q(\theta)(1-\beta)(f(z_N) - b)}{\rho + \delta_N + s + \beta p(\theta)} = k. \tag{3.13}$$

This job creation curve is equivalent to the standard formulation in search models except that we have two different types of filled jobs.

3.3 Educational decisions and equilibrium

3.3.1 Educational decision

Before entering the labour market natives must decide how much to invest into education. Each new entrant will start as an unemployed worker searching for a job. As the expected present value of unemployment, U_N, already incorporates any future periods of employment and unemployment, it is the expected total lifetime income of a native worker. Consequently, an individual entering the labour market will seek to maximise U_N by choosing the level of human capital z_N appropriately. Therefore native workers' optimisation problem is to maximise the net expected value of unemployment:

$$\max_{z_N} U_N - c z_N.$$

Using the closed form of U_N, the first order condition for a native worker is given by:

$$\frac{\beta p(\theta)}{(\rho+\delta_N)(\rho+\delta_N+s+\beta p(\theta))} f'(z_N) = c. \tag{3.14}$$

Any native workers chooses investment level z_N as to equalise the marginal return and the marginal cost c. For future reference we will refer to (3.14) as investment condition (IC). Note that both, a higher retirement rate δ_N and higher destruction rate s decrease the level of human capital investment because the time period to recoup the investment will be shorter. Additionally and with the same line of reasoning, increased labour market tightness θ increases the investment level, because unemployment spells are shorter. It is important to note that immigration does not directly influence the individual investment decision. However, immigration affects the equilibrium values of θ and z_N and thereby exerts an indirect effect on human capital investments.

3.3.2 Competitive equilibrium

A competitive equilibrium consists of a triple $\{z_N^E, \theta^E, u^E\}$ which simultaneously solves the job creation condition (JCC) of firms

$$G_1^E(z_N,\theta) := q(\theta)\left[\eta_U(\theta) J_I(\theta) + (1-\eta_U(\theta))\, J_N(\theta, z_N)\right] = k, \tag{3.15}$$

the investment condition (IC) of native workers

$$G_2^E(z_N,\theta) := \frac{\beta p(\theta)}{(\rho+\delta_N)(\rho+\delta_N+s+\beta p(\theta))} f'(z_N) = c, \tag{3.16}$$

and the Beveridge curve

$$u = \frac{\delta_N + s}{s + p(\theta) + \delta_N} + \frac{\mu}{\delta_I}\frac{\delta_I + s}{s + p(\theta) + \delta_I}. \tag{3.17}$$

The system is block recursive: the equilibrium values of the labour market tightness θ^E and the human capital z_N^E are completely identified by (3.13) and (3.14). Using the resulting θ^E in (3.4) then gives the equilibrium number of unemployed workers u^E. As shown in the appendix, both the JCC and the IC are positively sloped curves in (z_N, θ)-space. The IC starts at the origin and z_N is bounded from above by $\bar{z}$ according to $\{\bar{z}_N : f'(\bar{z}) = (\rho+\delta_N)\, c\}$. In contrast, the JCC starts at a positive θ with no upper bound for

z_N and θ. As shown in the appendix, both curves intersect at least once such that at least one equilibrium exists.

Our model exhibits the possibility of multiple equilibria. For reasons to become clear later, we restrict our analysis to stable equilibria only. To define a stable equilibrium we construct simple out-of-steady-state dynamics. Consider a triple $\{z_N^1, \theta^1, u^1\}$ in a sufficiently small neighbourhood of an equilibrium triple $\{z_N^E, \theta^E, u^E\}$. Assuming that labour market tightness θ will respond fastest to eliminate positive profits from open vacancies, we get a new θ according to $\theta^2 = \theta_{G_1^E=k}(z_N^1)$. This new θ^2 will induce workers to revise their investment decision to $z_N^2 = \theta_{G_2^E=c}(\theta^2)$. The sketched dynamics creates a series $\{z_{iN}, \theta_i, u_i\}_{i=1,\dots}$ which converges to a stable equilibrium $\{z_N^E, \theta^E, u^E\}$. With this kind of out-of-steady-state dynamics it is obvious that any triple in the vicinity of an unstable equilibrium will lead to an ever increasing or decreasing number of unemployed. We restrict our analysis to stable equilibria, because this kind of trend in the number of unemployed is contrary to facts.

With the characterisation of a stable equilibrium we can show that a stable equilibrium is reached if at the intersection of both equilibrium conditions the slope of the IC is steeper than the slope of the JCC: $\frac{d\theta}{dz_N} \mid_{G_1^E=k} < \frac{d\theta}{dz_N} \mid_{G_2^E=c}$.[21]

Figure 3.1 on the following page illustrates the JCC and the IC in (z_N, θ)-space for the case of a stable equilibrium. It illustrates the case of the competitive equilibrium for a human capital endowment of immigrants of $z_I = 10$ and an inflow rate $\mu = 0.01$ following our callibration in section 3.5.

3.3.3 Comparative statics results

In this section we analyse the impact of immigration on the labour market equilibrium. We discuss two different scenarios: (i) first-time immigration into a formerly closed economy ($\mu = 0$), and (ii) the case of sustained immigration into an economy with existing immigration ($\mu > 0$, $z_I > 0$). Throughout the following subsections we concentrate on stable equilibria. Note that immigration only affects the JCC, while the IC is unaffected: $G_{2,\mu}^E = G_{2,z_I}^E = 0$.[22] Therefore, we can concentrate on the influence of immigration on the JCC only.

[21] For the derivation of the slope of the JCC and IC, please consult the appendix.

[22] To simplify the exposition of our results we use the following notation to denote partial derivatives: $G_{2,k} \equiv \frac{\partial G_2^E}{\partial k}$.

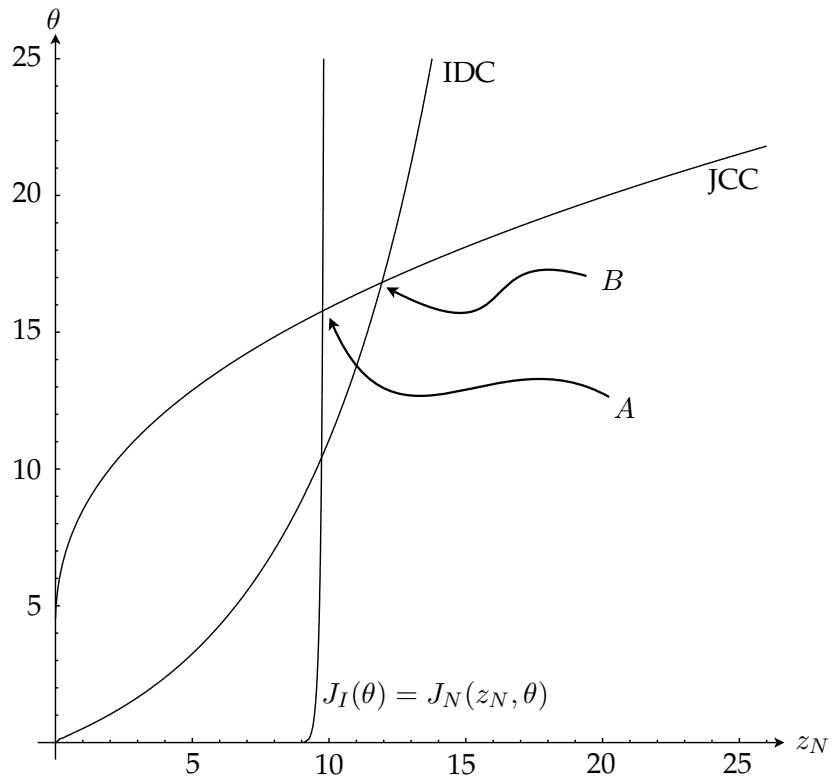

Figure 3.1: The IC and the JCC determining a stable equilibrium.

In the case of first-time migration, the calculation of the partial effect of z_I on the JCC reveals that $G^E_{1,z_I}\big|_{\mu=0} = 0$. However, the influence of the migration rate μ on the JCC is nonzero such that we derive the following results:

$$G^E_{1,\mu}\big|_{\mu=0} = \eta_{U,\mu}|_{\mu=0}\, q(\theta)(J_I - J_N) \begin{cases} > 0 & \text{if} \quad (J_I - J_N) > 0 \\ < 0 & \text{if} \quad (J_I - J_N) < 0, \end{cases} \tag{3.18}$$

because $\eta_{U,\mu}|_{\mu=0} > 0$. Together with $G^E_{1,z_N}\big|_{\mu=0} > 0$ and $G^E_{1,\theta}\Big|_{\mu=0} < 0$, we find that first-time immigration leads to a clockwise rotation of the JCC at its intersection with the curve $J_I(\theta) = J_N(\theta, z_N)$ (cf. figure 3.1).[23] With first-time immigration, the human capital endowment of potential migration (or the minimum requirement in terms of human capital for immigration) only matters for the comparative statics. First-time immigration will increase (decrease) the labour market tightness θ^E and native human capital z^E_N if

[23]The curve implicitly defined by $J_I(\theta; z_I) = J_N(\theta, z_N)$ is positively sloped in (z_N, θ)-space originating from $\tilde{z}_N$ which is the solution to $J_I(0, z_I) = J_N(0, \tilde{z}_N)$. For $\theta \to \infty$ we get $z_N \to z_I$.

the expected present value of migrant jobs J_I are more (less) valuable than comparative native jobs J_N. Due to a higher exit rate δ_I, potential immigrants need more human capital than natives to offset this negative effect. Thus, even if potential immigrants are better educated than native workers ($z_I > z_N$), the job value of natives can be higher ($J_I < J_N$), and both θ^E and z_N^E decrease.

To increase the labour market tightness θ^E and native human capital z_N^E, immigration policy has to aim at immigrants who are very well educated compared to natives. The native wage rate w_N is positively correlated with θ and z_N such that immigration policy directly influences native labour income. The same is true for native employment which will increase if $J_I > J_N$. The effect on total unemployment $u_I + u_N$ is ambiguous if immigration is high-skilled ($J_I > J_N$) because the decrease of native unemployment is counteracted by an increasing number of unemployed immigrants.

First time immigration is rather unlikely, because today most industrialised countries experience sustained immigration and try to implement a specific immigration policy given a certain history of migration $\{z_I, \mu\}$. A change of the immigration policy can be either a change in the number of immigrants by changing the inflow $d\mu$ or a change of the human capital standards dz_I.

We start by assuming that the equilibrium human capital of natives z_N is high enough such that $J_I < J_N$ holds. Either changing the amount of the existing quality of immigration ($d\mu \gtrless 0$) or changing the future quality of immigration ($dz_I \gtrless 0$) leads to the following change of the equilibrium values z_N^E, θ:[24]

$$\frac{d\theta^E}{d\mu}, \frac{dz_N^E}{d\mu} < 0, \quad \frac{d\theta^E}{dz_I}, \frac{dz_N^E}{dz_I} > 0, \qquad J_I < J_N. \tag{3.19}$$

Thus, we derive the same result as with first time immigration: both increased unskilled immigration and decreasing human capital standards will reduce equilibrium labour market tightness and human capital investments. This is because the expected present value of a filled job is reduced with a lower educational attainment of immigrants or an increased number of unskilled immigrants. Therefore, offering a vacancy is less attractive for firms thus reducing the number of vacancies and consequently the labour market tightness.[25]

[24]For a detailed derivation, please consult the appendix.

[25]Lewis (2003) estimates the possible impact of immigration on the labour demand of firms and finds support for technological adaption within firms depending on the skill mix of the respective labour markets.

Next, we assume that the existing immigration is sufficiently high-skilled such that $J_I > J_N$ holds. In this situation, a change of the migration policy will result in the following change of the equilibrium values:

$$\frac{d\theta^E}{d\mu}, \frac{dz_N^E}{d\mu} > 0, \quad \frac{d\theta^E}{dz_I}, \frac{dz_N^E}{dz_I} > 0, \qquad J_I > J_N \tag{3.20}$$

We get the result, that an increased number and higher quality of migrants will increase the labour market tightness and the human capital acquisition of natives. For later reference we summarise our findings in

Proposition 3.1. *In a stable equilibrium, an increase in the endowment of human capital of immigrants z_I^E increases θ^E and z_N^E and an increase in the flow of immigrants μ decreases θ^E and z_N^E in the case of $J_I < J_N$. If $J_I > J_N$ an increase in the endowment of human capital of immigrants z_I^E and an increased inflow of immigrants μ increases θ^E and z_N^E .*

In the context of search frictions, higher minimum requirement of human capital for immigrants leads to skill upgrading of native workers, because immigration increases the firms' incentive to supply jobs for workers in the host country. This contrasts with much of the literature which focuses either on competitive or rigid labour markets. In these models, high-skilled immigration reduces the incentive to invest into education (cf. Fuest and Thum, 2001). In contrast to the examined labour market institutions (competitive labour markets, efficient bargaining or monopoly union), the introduction of a search model reveals different immigration policy implications.

3.4 Efficiency and labour policies

3.4.1 Social planner

We assume that a social planner seeks to maximise exclusively the welfare of natives. Following Pissarides (2000), we apply the welfare function

$$\Omega = \int_0^\infty e^{-\rho\tau}(y_N + bu_N - k\theta u_N - \delta_N c z_N)d\tau. \tag{3.21}$$

The first additive term is the total income of natives with y_N denoting the average output per native worker, and bu_N denoting the leisure income of natives. The second term

summarises total cost: the search cost of firms for native workers ($k\theta u_N$) and the cost of education borne by natives entering the labour market ($\delta_N c z_N$). While shoosing u_N and z_N, the social planner has to obey the evolution of native unemployment

$$\dot{u}_N = \delta_N + s(1 - u_N) - p(\theta)u_N - \delta_N u_N, \tag{3.22}$$

as well as the evolution of average output

$$\dot{y}_N = p(\theta)u_N f(z_N) - (s + \delta_N)y_N. \tag{3.23}$$

The first term on the r.h.s of (3.23) represents the new jobs which are producing with a native worker. The second term represents the fraction of mature jobs which are destroyed at each instant of time.

Maximising (3.21) subject to (3.22) and (3.23) yields the following optimality conditions:[26]

$$G_1^o(z_N, \theta) \equiv \frac{p'(\theta)\,(f(z_N) - b)}{\rho + s + \delta_N + p(\theta) - p'(\theta)\theta} = k, \tag{3.24}$$

$$G_2^o(z_N, \theta) \equiv \frac{(\delta_N + s)\,p(\theta)}{\delta_N\,(s + \delta_N + p(\theta))\,(s + \delta_N + \rho)} f'(z_N) = c. \tag{3.25}$$

The solution of the optimisation problem is given by a triple $\{\theta^o, z_N^o, u_N^o\}$ solving the optimality conditions and the steady state condition for native unemployment, where the superscript o denotes the social optimum. Both optimality conditions are analogue to that of the market outcome. Equation (3.25) corresponds to the IC and equation (3.24) corresponds to the JCC. Because the social planner is only interested in the welfare of natives, these conditions do not reflect the fact that immigrants are active in the economy.

Comparising the IC of the market outcome (3.14) with the choice of the social planner (3.25) reveals that the amount of individual human capital investment z_N in the competitive environment is biased downwards and generates underinvestment:

Lemma 3.1. *The IC of native workers in the competitive environment generates underinvestment:* $z_N(\theta)|_{G_2^E = c} < z_N(\theta)|_{G_2^o = c}$.

Proof. Please consult the appendix. □

[26] For a detailed derivation of the solution of the optimisation problem, please consult the appendix.

In (z_N, θ)-space, the IC of the social planner is located to the right compared to the IC of the competitive situation. In these kind of search models, underinvestment is due to the timing of the investment decision: bargaining after the decision of education leads to hold-ups of native workers. Analysing the loci defined by (3.13) and (3.24) shows, that the bargaining power of workers β is crucial in determining whether the labour market tightness is higher or lower in the competitive environment compared to the choice of a social planner. In equilibrium matching models with free a entry condition, a certain bargaining power β^o will generate an efficient labour market tightness $\theta^E \mid_{z=z^o} = \theta^o \mid_{z=z^o}$ (cf. Hosios, 1990). Any other value of β will result in an inefficient labour market tightness. In the following, we will analyse how the inefficient labour market tightness depends on the human capital endowments of immigrants.

First, we analyse the efficiency of the market generated θ^E at the optimal investment level $\theta^E \mid_{z=z^o}$ if the expected present value of filled jobs is the same for both natives and immigrants: $J_N = J_I$. In this case, the efficient value β^o coincides with that of an economy without immigration: $\beta^o = \theta q'(\theta)/q(\theta)$. In this case the bargaining power is equivalent to the elasticity of the application rate with respect to the labour market tightness (cf. Pissarides, 2000). With a β larger (smaller) than the efficient value β^o we have too small (large) labour market tightness. Second, we have to differentiate the cases of immigration resulting in different expected present values of filled jobs of immigrant and natives $J_N \neq J_I$. In this case, the existing immigration in the host country plays a significant role for the threshold value β^o. The efficient value does not only depend on the elasticity of the application rate $q(\theta)$, but also on the human capital endowments of natives, z_N, and immigrants, z_I. In fact, the educational attainment of immigrants in the host country compared to the natives ($J^e \gtrless J_N$) is decisive for the efficient bargaining power β^o. We can not explicitly solve for the new efficient value β_I^o. However, β_I^o is smaller (larger) than β^o if immigration is relatively low-skilled (high-skilled). Therefore, an economy with mainly low-skilled (high-skilled) immigrants is characterised by a smaller (larger) efficient bargaining power than in an economy without immigrants. Most importantly, with β larger (smaller) than the efficient value β_I^o, we have too small (large) labour market tightness.

Lemma 3.2. *In the case of $J_N \neq J_I$: If the bargaining power of workers β is large enough: $\beta > \beta_I^o$ (small enough: $\beta < \beta_I^o$), the JCC in the competitive environment generates too small market tightness: $\theta(z_N)|_{G_1^E=k} < \theta(z_N)|_{G_1^o=k}$ (too large market tightness: $\theta^E \mid_{z=z^o} > \theta^o$). If*

$\beta = \beta_I^o$, it generates the optimal market tightness $\theta^E \mid_{z=z^o} = \theta^o$. For the case of $J_N = J_I$, the efficient labour market tightness is given by $\beta^o = \beta_I^o = \theta q'(\theta)/q(\theta)$.

Proof. Please consult the appendix. □

The lemmata 3.1 and 3.2 reflect the inefficiency of the competitive equilibrium. The underinvestment in human capital always exists irrespective of the actual value of θ^E. However, the labour market tightness is either too small or too high depending on the bargaining power of workers as much as on the educational attainment of immigrants in the host country. We get therefore the same result as Acemoglu and Shimer (1999) and Sato and Sugiura (2003) with the same mechanism at work.

3.4.2 Education subsidies

As shown by the first proposition, directed immigration policy – concerning human capital characteristics and/or flows of immigrants – affects the JCC directly. To reach the social optimum, we need a policy tool which allows us to affect the IC. By introducing education subsidies per invested unit h for native workers, the IC is changed according to:

$$\frac{\beta p(\theta)}{(\rho + \delta_N)(\rho + \delta_N + s + \beta p(\theta))} f'(z_N) = c - h.$$

At a given labour market tightness, the introduction of a subsidy leads to increased investment in human capital. In (z_N, θ)-space this results in a shift of the IC-curve to the right (cf. figure 3.1). However, increased investment in human capital makes it more profitable for a firm to open a vacancy which in turn increases the labour market tightness. The equilibrium outcome of an education subsidy is described in

Proposition 3.2. *In a stable equilibrium, an increase in a subsidy to a unit investment in human capital h increases θ^E and z_N^E and lowers the unemployment rate.*

Proof. Please consult the appendix. □

3.4.3 Pareto-optimal immigration and labour policy

We have shown that education subsidies affect the incentives to train and lead to more human capital investments by natives. Immigration policies – either by changing the human capital composition of immigrants or by changing the inflow of immigrants into the host country – will have a direct effect on the job creation of firms. Combining these policies, we can obtain the Pareto-optimal human capital investment of natives and labour market tightness thereby removing the hold-up problem.

The starting point for our analysis are the properties of the competitive equilibrium. The investment of native workers always has to be subsidised to solve the problem of underinvestment (see lemma 3.1). Therefore, $h^* > 0$ should be the appropriate labour market policy which leads to a shift of the IC towards the social planner equilibrium (see proposition 3.2).

With a change either in the flows of immigrants (μ) and/or in the characteristics of immigration (z_I), we can affect the job creation of firms and thus correct for a non-optimal labour market tightness (lemma 3.2). The effect of an increase of z_I always increases z_N and θ, independently of the human capital endowment of existing immigrants ($J_I \gtrless J_N$). The effects of an increase in the flow of immigrants μ depend on the existing human capital endowment of immigrants (see proposition 3.1). Thus, the Pareto-optimal immigration policy has to be a combination of policies (h^*, z_I^*, μ^*) which increases z_N^E and either increases or decreases θ^E. For example, in the case of an economy with low-skilled immigration and a too high bargaining power, the labour market tightness would be too low and underinvestment in human capital exists. Therefore, we introduce education subsidies h to increase z_N^E and θ^E and we could increase the human capital endowment of immigrants z_I or decrease the inflow of low-skilled immigrants μ.

Proposition 3.3. *Human capital investments are subsidised with a labour policy $h^* > 0$. If $\beta < \beta_I^o$ we need fewer skilled immigrants to correct for the too high labour market tightness. If $\beta > \beta_I^o$, we need higher skilled immigrants to correct for the too small labour market tightness: $z_I^* > z_I$. If $\beta \gtrless \beta_I^o$ and $J_I > J_N$, we need more (less) high-skilled immigrants to correct for the too low (high) labour market tightness: $\mu^* \gtrless \mu$. If $\beta \gtrless \beta_I^o$ and $J_I < J_N$, we need less (more) low-skilled immigrants to correct for the too low (high) labour market tightness. A combination of these policies (h^*, z_I^*, μ^*) induce the Pareto-optimal equilibrium of the social planner.*

Proof. Please consult the appendix. □

3.5 Numerical example

The following numerical example shall illustrate the results derived from our theoretical analysis. To this extend, we calibrate our model for the US economy (cf. Albrecht and Vroman (2002) for a comparable illustration of their model). The matching function is assumed to be of Cobb-Douglas type $m(u,v) = 2\sqrt{uv}$ which implying an arrival rate $p(\theta) = 2\sqrt{\theta}$. Thus, the elasticity of the matching function is 0.5 (cf. Petrongolo and Pissarides (2001)). The bargaining power β is also set to 0.5 for the US which is in line with the estimates of Abowd and Allain (1996). For the values of the other exogenous variables, we follow closely the specification choosen by Albrecht and Vroman (2002): $\delta_N = 0.025$, $\delta_I = 0.05$, $\mu = 0.01$, $s = 0.2$, $\rho = 0.05$, $b = 0.1$, $c = 0.1$, $k = 0.2$. The job destruction rate is lower in our case because we have not included on-the-job search in our model (cf. Albrecht and Vroman (2002)).[27] With a $\delta_N = 0.025$, we get an average working life time of 40 years. The steady-state stock of immigrants of $I = \mu/\delta_I = 0.2$ meaning that about 17% of the total population are immigrants. This is a comparable low number of immigrants: the highest number of immigrants has Dade county in the US: there, 40 per cent of the total population are immigrants. The production function takes the following form: $f(z) = 0.1z^{0.5} + b$. The baseline scenario were chosen by the following criteria: if the exogenous parameters and the endogenous variables are realistic and if we may generate plausible characteristics of our equilibria and of our comparative static results. Table 3.1 shows both type of equilibrium in the baseline scenario.

z_I	μ	h	z_N	θ	$p(\theta)$	u_I	u_N	U_I	U_N
Competitive Equilibrium									
20	0.01	0	31.8	2.29	3.03	0.076	0.069	4.73	8.94
Pareto-equilibrium									
20	0.01	0	246.5	7.11	5.34	0.040	0.045	5.02	21.64

Table 3.1: Both types of equilibrium: competitive and Pareto

($\delta_N = 0.025$, $\delta_I = 0.05$, $s = 0.2$, $\rho = 0.05$, $b = 0.1$, $c = 0.1$, $k = 0.2$, $\beta = 0.5$)

[27] Shimer (2005) gives an annual job separation rate of 0.408. Petrongolo and Pissarides (2001) show that on-the-job changes represented about 20 per cent in the US to up to 40 per cent in the UK of total hires.

In the baseline scenario, immigrants have an about 50% lower labour market productivity than natives ($z_I = 20$ and $z_N = 32$) so that we start with a relatively low-skilled immigration. We have not yet included any education subsidies ($h = 0$) which would foster native educational attainment. Furthermore, the competitive educational attainment $z_N^E = 32$ is quite lower than the comparable Pareto-optimal educational attainment $z_N^o = 247$ illustrating the existing hold-up problem. The unemployment rate of immigrants is only slightly higher than the unemployment rate of natives. The reason is that firms accept any arriving immigrant for their vacancy. In the competitive equilibrium, the labour market tightness is $\theta^E = 2.29$ which leads to a vacancy rate of $v^E = 0.19$. The average duration of native unemployment is about 4 months ($12 \times (1/3.03) = 3.96$), whereas the average duration of immigrant unemployment is only 0.8 months ($12 \times (0.2/3.03) = 0.79$). The average duration of a vacancy is about 9 months ($12 \times (2.29/3.03) = 9.06$). The large average duration of a vacancy comes from the low arrival rate of jobs. Due to the non-existence of on-the-job search, the monthly job finding rate is lower than the estimates of 0.45 to 0.54 by Shimer (2005) and Hall (2005). This lower job finding rate translates into a higher duration of vacancies (Albrecht and Vroman (2002) receive comparable values for the duration of a vacancy and unemployment in their simulation). Obviously, the value of unemployment is higher for natives than for immigrants as well as wages for natives are higher than for immigrants ($w_N^E = 4.80$ and $w_I^E = 2.64$) and the values of the different filled jobs ($J_N^E = 0.157$ and $J_I^E = 0.123$).

The baseline scenario generates two inefficiencies: first, as indicated in table 3.1, underinvestment in human capital and second, the optimal bargaining power is $\beta^o = 0.46$, which means that the existing bargaining power is set too high ($\beta = 0.5$) and the existing labour market tightness is too low. Thus, we would have to admit higher skilled immigrants or more skilled immigrants. Because the social planner's problem is independent of immigration, any of the following results can be compared to the outcome of the planner's problem of the base line scenario.

We discuss the case of an economy with low-skilled immigration (compared to the level of native human capital) and a too small labour market tightness. First, we solely increase either the human capital endowment of immigrants and second, we augment the number of high-skilled immigrants. The labour market tightness θ^E and the educational attainment of natives z_N^E change as follows.

z_I	μ	h	z_N^E	θ^E	$p(\theta)$	u_I	u_N	U_I	U_N
Higher skilled immigrants									
20	0.01	0	31.8	2.29	3.03	0.076	0.069	4.73	8.94
100	0.01	0	32.8	2.78	3.33	0.069	0.063	9.47	9.14
200	0.01	0	33.0	3.14	3.54	0.065	0.060	13.1	9.26
More high-skilled immigrants									
100	0.01	0	32.8	2.78	3.33	0.069	0.063	9.47	9.14
100	0.02	0	33.2	3.03	3.48	0.067	0.061	9.53	9.22
100	0.03	0	33.4	3.21	3.59	0.065	0.059	9.57	9.27

Table 3.2: Directed immigration policy

($\delta_N = 0.025$, $\delta_I = 0.05$, $s = 0.2$, $\rho = 0.05$, $b = 0.1$, $c = 0.1$, $k = 0.2$, $\beta = 0.5$)

The upper row of table 3.2 shows the impact of an immigration policy which controls the "quality" of immigration meaning the educational endowment of immigrants. The labour market tightness increases due to the higher skilled immigrants ($d\theta^E/dz_I > 0$) as well as the educational attainment of native workers ($dz_N^E/dz_I > 0$). The reason is the increased number of vacancies in the labour market: v increases from 0.19 to 0.21 and finally to 0.23. Therefore, higher skilled immigration will lead to less unemployment among immigrants but also among native workers. Obviously, the value of unemployment, immigrant wages and the value of an immigrant filled job is higher than the comparable values of native workers. Still, the increase in educational endowment has to be very large. In the second panel, we analyse the effects of an increase of the number of high-skilled immigrants for our labour market. As in the case of higher educational attainment, we get an increase of the labour market tightness ($d\theta^E/d\mu > 0$) and of native human capital ($dz_N^E/d\mu > 0$). The number of immigrants increases from about 17 per cent of the total population to 28 per cent ($\mu = 0.02$) and to 37.5 per cent ($\mu = 0.03$). Compared to local labour markets like London or Miami, these figures are still lower (cf. Dustmann et al. 2003; Chiswick and Sullivan 2005). With the higher number of immigrants, the "liquidity" of the labour market increases and the number of vacancies increases as well ($v = 0.265$ and $v = 0.315$). In contrast to the immigration policy of the first panel, the share of unemployed immigrants increases ($\eta = 0.31$ and $\eta = 0.40$) and immigrant wages increases only slightly ($w_I = 5.31$ and $w_I = 5.33$).

Now we combine the proposed immigration policies with education subsidies ($h > 0$):

z_I	μ	h	z_N	θ	$p(\theta)$	u_I	u_N	U_I	U_N
More & Higher skilled immigrants & Education subsidies									
100	0.02	0.01	41.3	3.25	3.60	0.065	0.059	9.57	10.04
200	0.03	0.02	54.3	4.43	4.21	0.056	0.051	13.37	11.32
200	0.03	0.03	71.5	4.73	4.35	0.054	0.049	13.43	12.64

Table 3.3: Immigration policy and education subsidies

($\delta_N = 0.025$, $\delta_I = 0.05$, $s = 0.2$, $\rho = 0.05$, $b = 0.1$, $c = 0.1$, $k = 0.2$, $\beta = 0.5$)

Obviously, education subsidies forster native human capital investments more than the proposed immigration policies. Therefore, the increase in educational attainment z_N is relatively higher than on the labour market tightness θ. The education subsidies must be quite a high to attain the Pareto-optimum. However, in a number of industrialised countries, most of the secondary and tertiary education is costless (see, for example, Germany as an extreme case). The number of vacancies v, the value of a filled (either immigrant or native) job, wages and the value of unemployment increases.

3.6 Extension

In the US and the UK, the distribution of educational attainment of immigrants is bimodal with both a large number of highly skilled immigrants and a large number of low-skilled immigrants. For example Chiswick and Sullivan (2005) report for the US, that immigrants from Asia, Europe and Canada mostly embody at least the same human capital as US natives of the respective group. But immigrants from Mexico and Latin America have significantly lower educational attainment than their native counterparts in the group of unskilled workers. We can discuss this kind of immigration if we consider perfectly segmented labour markets between skill groups in the spirit of Mortensen and Pissarides (1999).

Suppose that an economy consists of two different labour markets, one for high-skilled workers and one for low-skilled workers. Both labour markets are perfectly separated meaning that a high-skilled worker can not switch to the low-skilled labour market and vice versa. Assume further that individuals differ with respect to their abilities $a \in [0, \infty)$ distributed according to some general distribution function $g(a)$. High-skilled workers acquire the skills needed on their respective labour market at university. If access to universities requires a certain ability $\bar{a}$, individuals with abilities $a \leq \bar{a}$ work as

low-skilled workers and those with $a > \bar{a}$ work as high-skilled workers.[28] Using this simple setup we end up with two segmented labour markets instead of N segmented labour markets as modelled by Mortensen and Pissarides (1999).

Considering the bimodal immigration of, e.g., the US or the UK, our analysis of the impact of immigration applies separately for both labour markets. We have immigration of high-skilled workers on the labour market of high-skilled natives which is comparatively better skilled than their native counterparts. Simultaneously, immigration of low-skilled workers takes place on the labour market of low-skilled natives. First, entrance of high-skilled immigrants (resulting from a higher μ) or higher skilled immigrants (resulting from a higher z_I) lead to increasing job creation of firms and higher wages of high-skilled natives. Therefore, native workers have a higher incentive to invest more into education. Second, the same analysis applies for the impact of immigration of low-skilled workers. If immigrants in the low-skilled sector are comparatively less skilled than native low-skilled workers, firms in the low-skilled sector will react by opening less vacancies in this sector and the wage rate will decline for low-skilled workers. The total effect will be higher investments in education by native high-skilled workers due to their wage increases. The labour market prospects of low-skilled workers deteriorate due to decreased wages. This summarises a possible impact of the bimodality of US immigration on the existing wage inequality (cf. Borjas et al., 1997).

3.7 Conclusions

We introduce immigration into a search model of equilibrium unemployment. This allows us to model immigration in terms of flows and its characteristics in terms of human capital. Because of a positive probability of returning to their home countries, immigrants receive lower wages and have a higher unemployment rate compared to natives. We can show that an immigration policy which is concerned about the human capital endowment of immigrants and/or the number of immigrants has a decisive impact on the educational decision of natives. Immigration policy favouring higher skilled immigrants will increase the wage rate for the group of high-skilled workers because firms have incentives to increase the number of vacancies. This induces natives to invest more in education. Furthermore, the problem of underinvestment in human capital can be solved by choosing a combination of education subsidies and a directed immigration

[28] The individual with ability $\bar{a}$ is indifferent between going to university or working as low-skilled worker.

policy. Education subsidies foster the investment decision of natives and the appropriate immigration policy generates Pareto-improving job creation by firms. The model can be extended to introduce bimodal immigration concerning the educational attainment of immigrants. Applying perfectly segmented labour markets in combination with an immigration of high and low-skilled workers results in higher native investment in human capital by high-skilled natives and lower wages of low-skilled natives.

3.A Appendix

3.A.1 Derivation of the wage setting equation (3.10)

Maximisation of the Nash product (3.9) yields

$$w_i = \beta f(z_i) + (1-\beta)(\delta_i + \rho)U_i \quad i = I, N. \tag{A3.1}$$

Substitution of (A3.1) in(3.6) gives:

$$W_i = \frac{\beta f(z_i) + ((1-\beta)(\rho + \delta_i) + s)\, U_i}{\rho + \delta_i + s} \quad i = I, N. \tag{A3.2}$$

Substitution of (A3.2) in (3.5) we end up with reservation wage:

$$(\rho + \delta_i)\, U_i = \frac{b(\rho + \delta_i + s) + p(\theta)\beta f(z_i)}{\rho + \delta_i + s + p(\theta)\beta} \quad i = I, N. \tag{A3.3}$$

Substitution of the reservation wage in (A3.1) yields the wage setting equation (3.10).

3.A.2 Existence of the equilibrium

Proof. It is to show that the equilibrium $\{z_N^E, \theta^E, u^E\}$ exists. The functions $G_1^E(\theta, z_N)$ and $G_2^E(\theta, z_N)$ are continuous and $G_{i,z_N}^E \neq 0$ $i = 1, 2$ on the open interval $(0, \infty)$. Therefore, we can apply the implicit function theorem and express z_N as a function of θ denoted by: $z_{1N}(\theta)$, $z_{2N}(\theta)$. Because $\lim_{\theta \to 0} \lim_{z_N \to 0} G_1^E(\theta, z_N) = \infty > k$ the domain of $z_{1N}(\theta)$ is the open interval $(\bar{\theta}_1, \infty)$ with $\bar{\theta}_1 > 0$ and the domain of $z_{2N}(\theta)$ is the open interval $(0, \infty)$. Analysing these functions at their respective domain limits reveals: $\lim_{\theta \to \bar{\theta}_1} z_{1N}(\theta) = 0$ and $\lim_{\theta \to \infty} z_{1N}(\theta) = \infty$. Given that $\lim_{\theta \to \infty} p(\theta) = \infty$, we get $\lim_{\theta \to \infty} z_{2N}(\theta) = \bar{z}_2$ where $\bar{z}_2$ is defined by: $\bar{z}_2 := \{z_2 : f'(z_2) = (\rho + \delta_N)\, c\}$. At the lower boundary we get $\lim_{\theta \to 0} z_{2N}(\theta) = 0$. Next we define the function $\Gamma(\theta) = z_{2N}(\theta) - z_{1N}(\theta)$. Using the previous results we get $\lim_{\theta \to \bar{\theta}_1} \Gamma(\theta) > 0$ because $z_{2N}(\theta)$ is strictly increasing. Furthermore we get $\lim_{\theta \to \infty} \Gamma(\theta) = -\infty$. Thus, the intermediate value theorem guarantees at least one θ' such that $\Gamma(\theta') = 0$. This concludes the proof that at least one equilibrium exists. □

3.A.3 Slope of the IC and JCC

Differentiation of $G_1^E(\theta, z_N)$ and $G_2^E(\theta, z_N)$ with respect to θ and z_N gives:

$$\begin{aligned} G_{1,\theta}^E &= \frac{dq(\theta)\eta_U}{d\theta} J_I + \frac{dq(\theta)\,(1-\eta_U)}{d\theta} J_N \\ &\quad + q(\theta)\eta_U J_{I,\theta} + q(\theta)\,(1-\eta_U)\,J_{N,\theta} < 0, \qquad \text{(A3.4)} \\ G_{1,z_N}^E &= q(\theta)\,(1-\eta_U(\theta))\,J_{N,z_N} > 0, \qquad \text{(A3.5)} \\ G_{2,\theta}^E &= \frac{\beta p'(\theta)\,(\rho+\delta_N+s)}{(\rho+\delta_N)\,(\rho+\delta_N+s+\beta p(\theta))^2} f'(z_N) > 0, \qquad \text{(A3.6)} \\ G_{2,z_N}^E &= \frac{\beta p(\theta)}{(\rho+\delta_N)\,(\rho+\delta_N+s+\beta p(\theta))} f''(z_N) < 0, \qquad \text{(A3.7)} \end{aligned}$$

The slope of the JCC and the IC can then be calculated as:

$$\left.\frac{d\theta}{dz_N}\right|_{G_1^E(\cdot)=k} > 0, \quad \left.\frac{d\theta}{dz_N}\right|_{G_2^E(\cdot)=c} > 0.$$

3.A.4 Comparative statics

The first two derivatives are needed for the further analysis:

$$\frac{\partial \eta_U}{\partial \mu} = (1-\eta_U)\frac{1}{\delta_I}\frac{\delta_I+s}{\delta_I+s+p(\theta)} > 0,$$

$$\frac{\partial \eta_U}{\partial \theta} = p'(\theta)\eta_U(1-\eta_U)\left(\frac{1}{\delta_I+s+p(\theta)} - \frac{1}{\delta_N+s+p(\theta)}\right) > 0.$$

The derivatives of the JCC and the IC in the competitive equilibrium look as follows:

$$G_{1\mu}^E = \frac{d\eta_U}{d\mu}(J_I - J_N) \begin{cases} > 0 & (J_I - J_N) > 0 \\ < 0 & (J_I - J_N) < 0 \end{cases},$$

$$G_{1z_I}^E = \eta_U(\theta)\frac{q(\theta)(1-\beta)f'(z_I)}{\rho+\delta_I+s+\beta p(\theta)} > 0.$$

3.A.5 Optimality conditions

Given the following Hamiltonian:

$$H = e^{-\rho\tau}[y_N + bu_N - k\theta u_N - \delta_N c z_N] + \lambda_1\{\delta_N + s(1-u_N) - [p(\theta)+\delta_N]u_N\} \\ +\lambda_2\{p(\theta)u_N f(z_N) - (s+\delta_N)y_N\},$$

we get the following first order conditions:

$$\frac{\partial H}{\partial u_N} = e^{-\rho\tau}(b-k\theta) - \lambda_1[s+p(\theta)+\delta_N] + \lambda_2 p(\theta) f(z_N) + \dot{\lambda}_1 = 0, \quad \text{(A3.8)}$$

$$\frac{\partial H}{\partial y_N} = e^{-\rho\tau} - \lambda_2(s+\delta_N) + \dot{\lambda}_2 = 0, \quad \text{(A3.9)}$$

$$\frac{\partial H}{\partial \theta} = -e^{-\rho\tau} k u_N - \lambda_1 p'(\theta) u_N + \lambda_2 p'(\theta) u_N f(z_N) = 0, \quad \text{(A3.10)}$$

$$\frac{\partial H}{\partial z_N} = -e^{-\rho\tau}\delta_N c + \lambda_2 p(\theta) u_N f'(z_N) = 0. \quad \text{(A3.11)}$$

Solving the differential equation (A3.9) and equating the solution at the steady state $\dot{\lambda}_2/\lambda_2 = -\rho$ we yield the steady state value of λ_2:

$$\lambda_2 = \frac{e^{-\rho\tau}}{s+\delta_N+\rho}.$$

Replacing λ_2 in (A3.8), solving the differential equation and equating the solution at the steady state $\dot{\lambda}_1/\lambda_1 = -\rho$ gives:

$$\lambda_1 = \frac{e^{-\rho\tau}}{\rho+s+p(\theta)+\delta_N}\left((b-k\theta) + \frac{p(\theta)f(z_N)}{s+\delta_N+\rho}\right).$$

Using λ_2 in (A3.11) and solving for c yields (3.25):

$$\frac{p(\theta)u_N}{\delta_N(s+\delta_N+\rho)} f'(z_N) = c.$$

Replacing $u_N$with the steady state value yields (3.24):

$$\frac{(\delta_N+s)\,p(\theta)}{\delta_N\,(s+\delta_N+p(\theta))\,(s+\delta_N+\rho)} f'(z_N) = c.$$

Using λ_1 and λ_2 in (A3.10) and solving for k gives:

$$\frac{p'(\theta)\left(f(z_N)-b\right)}{\rho+s+\delta_N+p(\theta)-p'(\theta)\theta}=k.$$

3.A.6 Proof of Lemma 3.1

Proof. We need to compare the loci defined by (3.14) and (3.25). Assume that $z_N(\theta)|_{G_2^E=c} < z_N(\theta)|_{G_2^o=c}$ holds for any $\theta=\bar{\theta}$. This implies the following inequality:

$$\frac{\beta p(\bar{\theta})}{(\rho+\delta_N)\left(\rho+A+\beta p(\bar{\theta})\right)} < \frac{Ap(\bar{\theta})}{\delta_N\left(p(\bar{\theta})+A\right)(A+\rho)},$$

with $A\equiv\delta_N+s$. First note that if the inequality holds for $\beta=1$ it will also hold for $\beta<1$ because the LHS increases in β. Therefore we set $\beta=1$ and check whether this is true or not. Reorganising terms yields:

$$\begin{aligned}\delta_N\left(p(\bar{\theta})+A\right)(A+\rho) &< A\left(\rho+\delta_N\right)\left(\rho+A+p(\bar{\theta})\right),\\ \delta_N p(\bar{\theta}) &< A\rho+A^2+Ap(\bar{\theta}).\end{aligned}$$

which by using the definition of A is true for any value of $\bar{\theta}$ and completes the proof. □

3.A.7 Proof Lemma 3.2

Proof. Assume that $z_N^E=z_N^o$. First we consider an economy without immigration $\mu=0$. Evaluating (3.13) and (3.24) at $z_N^E=z_N^o$ and comparing both terms yields:

$$\frac{(1-\beta)p(\theta^E)/\theta^E}{\rho+\delta_N+s+\beta p(\theta^E)}=\frac{p'(\theta^o)}{s+\delta_N+\rho+p(\theta^o)-\theta^o p'(\theta^o)}$$

$\theta^E=\theta^o$ holds if $\beta=\frac{p(\theta^E)-\theta^E p'(\theta^E)}{p(\theta^E)}=\theta^E\frac{q'(\theta^E)}{q(\theta^E)}\equiv\tilde{\beta}$. This is the well known Hosios-condition for an efficient bargaining power of workers (Hosios, 1990). Note that, because $G_{1,\theta}^E<0$ and $G_{1,\beta}^E<0$ we can conclude that for any $\beta\gtrless\tilde{\beta}\;\theta^E\lesseqgtr\theta^o$.

Next we are considering an economy with immigration. With immigration we can not analytically find an efficient $\tilde{\beta}$. However, an efficient $\tilde{\beta}$ solves the following equation:

$$\tilde{\beta} := \{\beta : q(\theta^o)J^e(\theta^o, z_N^o; \beta) = G_1^o(z_N^o, \theta^o)\}$$

Note, that we have to differentiate the two possible cases $J_I > J^e > J_N$ and $J_N > J^e > J_I$. Furthermore, because $G^E_{1,\beta} < 0$ and $G^E_{1,\theta} < 0$ with same line of reasoning as before we can conclude that for any $\beta \gtrless \tilde{\beta}_I \; \theta^E \lesseqgtr \theta^o$. □

3.A.8 Proof Proposition 3.1

Proof. We are in a stable equilibrium: $G^E_{1\theta}G^E_{2z_N} - G^E_{2\theta}G^E_{1z_N} > 0$:

$$\frac{d\theta^E}{d\mu} = -\frac{G^E_{1\mu}G^E_{2z_N}}{G^E_{1\theta}G^E_{2z_N} - G^E_{2\theta}G^E_{1z_N}} \begin{cases} > 0 & iff \;\; (J_I - J_N) > 0 \\ < 0 & iff \;\; (J_I - J_N) < 0 \end{cases},$$

$$\frac{dz^E_N}{d\mu} = -\frac{-G^E_{2\theta}G^E_{1\mu}}{G^E_{1\theta}G^E_{2z_N} - G^E_{2\theta}G^E_{1z_N}} \begin{cases} > 0 & iff \;\; (J_I - J_N) > 0 \\ < 0 & iff \;\; (J_I - J_N) < 0 \end{cases}.$$

$$\frac{d\theta^E}{dz_I} = -\frac{G^E_{1z_I}G^E_{2z_N}}{G^E_{1\theta}G^E_{2z_N} - G^E_{2\theta}G^E_{1z_N}} > 0,$$

$$\frac{dz^E_N}{dz_I} = -\frac{-G^E_{2\theta}G^E_{1z_I}}{G^E_{1\theta}G^E_{2z_N} - G^E_{2\theta}G^E_{1z_N}} > 0.$$

The number of unemployed workers changes as follows:

$$du = \left.\frac{\partial u}{\partial \theta}\right|_{\mu=0} d\theta + \left.\frac{\partial u}{\partial \mu}\right|_{\mu=0} d\mu,$$

$$du = -\frac{(s+\delta_N)\, p'(\theta)}{(s+\delta_N+p(\theta))^2} d\theta + \frac{1}{\delta_I}\frac{(s+\delta_I)}{(s+\delta_I+p(\theta))} d\mu.$$

□

3.A.9 Proof Proposition 3.2

Proof. For the stable equilibrium $G^E_{1\theta} < 0$ and $G^E_{1\theta}G^E_{2z_N} - G^E_{2\theta}G^E_{1z_N} > 0$ hold:

$$\frac{d\theta^E}{dh} = \frac{G^E_{1z_N}}{G^E_{1\theta}G^E_{2z_N} - G^E_{2\theta}G^E_{1z_N}} > 0,$$
$$\frac{dz^E_N}{dh} = -\frac{G^E_{1\theta}}{G^E_{1\theta}G^E_{2z_N} - G^E_{2\theta}G^E_{1z_N}} > 0.$$

□

3.A.10 Proof Proposition 3.3

Proof. We will compare the JCC and the IC in the competitive equilibrium with their counterparts of the social planner. Education subsidies shall be positive: $h^* > 0$ which can be shown by the following expression:

$$h^* = f'(z_N)\left[\frac{(\delta_N + s)\,p(\theta)}{\delta_N\,(\delta_N + s + \delta_N)\,(s + p(\theta) + \rho)} - \frac{\beta p(\theta)}{(\rho + \delta_N)\,(\rho + \delta_N + s + \beta p(\theta))}\right] > 0,$$

where the first expression is the IC of the social planner (3.25) and the second expression is the IC of the competitive equilibrium (3.14).

The comparison of the JCC cannot not be made in the same way. We have to rely on the comparative static results for changes in $z_I$and μ. First, we consider a change in z_I: $\frac{d\theta^E}{dz_I}, \frac{dz^E_N}{dz_I} > 0$ irrespective of the expected present value of a filled job. If $\beta < \beta^o_I$, we have too high labour market tightness and therefore we need lower educational attainment of immigrants $z^*_I < z_I$. For a $\beta > \beta^o_I$, the educational attainment has to be higher: $z^*_I > z_I$.

Second we consider a change in the inflow of immigrants μ: if $J_I < J_N$, we have less skilled immigrants compared to natives coming into the host country. The following comparative static will then apply $\frac{d\theta^E}{d\mu}, \frac{dz^E_N}{d\mu} < 0$. With this kind of immigration and a $\beta > \beta^o_I$, we have too small labour market tightness and we have to decrease the inflow

of immigrants $\mu^* < \mu$. For a $\beta < \beta_I^o$, we need $\mu^* < \mu$. If $J_I > J_N$ then $\frac{d\theta^E}{d\mu}, \frac{dz_N^E}{d\mu} > 0$. With a $\beta > \beta_I^o$, we have too small labour market tightness and we have to increase the inflow of immigrants $\mu^* > \mu$. For a $\beta < \beta_I^o$, we need $\mu^* < \mu$. □

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CHAPTER 4

The impact of immigration on local labour markets reloaded

4.1 Introduction

During the 1980's, wage inequality in the US has increased sharply: the college premium rose by 0.92 per cent per year from 1979 to 1995 (cf. Autor et al., 1998). Surprisingly, this increase in wage inequality was almost identical for all local labour markets of the US although some of these local labour markets (e.g., Los Angeles or Dade County) experienced massive inflows of low-skilled immigrants during the same time.[1] Thus, most of the empirical literature on immigration finds only a negligible effect on native wages (cf. Card, 2001) implying that relative wages for low-skilled native workers remain the same over local labour markets in the US. These empirical studies on local labour markets typically control for associated absorbing effects like (i) local demand shocks which attract immigration, (ii) a changing industry structure (according to the Rybczynski theorem) and (iii) native out-migration which offsets the inflows of immigrants into local labour markets. Card (2005) concludes that there is only a negligible impact of immigration on native wages in local labour markets.

In order to explain this empirical puzzle, Lewis (2003, 2004) stresses the so-called Acemoglu effect (cf. Acemoglu, 1998, 2002, 2003; Beaudry and Green, 2003). According to that hypothesis, an exogenous supply shock like massive inflows of low-skilled immigrants leads firms to adapt to low-skilled intensive technologies. Lewis (2003, 2004) finds first evidence of unskill biased technological change in local labour markets with high immigration rates which leads to wage neutrality of immigration. However, it is hardly possible to reconcile these empirical findings with the theoretical explanation. The reasons are twofold. First, the economy-wide increase in wage inequality in favour of high-skilled labour and unskill biased technological change in local labour markets cannot be simultaneously explained by an Acemoglu effect (in the sense of his original formulation). For local labour markets with immigration inflows, the rise of high-skilled labour would just be compensated by immigration resulting in no change in wage inequality at all. On the other hand, the rise in relative high-skilled labour supply in local labour markets with no immigration would generate an Acemoglu effect as argued by Acemoglu, 1998, 2002, 2003; Beaudry and Green, 2003. Thus, we must have different explanations of the economy-wide increase in wage inequality as e.g., outsourcing (cf.

[1] Immigrants tend to concentrate to certain geographical areas: in Dade County 45 per cent of the total population are foreign-born (cf. Chiswick and Sullivan, 2005). Similar developments can be observed in other countries like the UK: London contains more than 40 per cent of all immigrants (Dustmann et al., 2003).

Feenstra and Hanson, 1999), trade with developing countries (cf. Wood, 1998) or demand changes (cf. Krugman, 1994; Berman et al., 1998). Second, the Acemoglu effect must exactly neutralise the wage effects of immigration meaning that the technology adoption of firms leads to constant low-skilled native wages. A rigorous application of the Acemoglu effect would imply a decrease in wage inequality in the local labour market that experienced low-skilled immigration. Thus, from a theoretical viewpoint, one cannot explain the economy-wide increase in wage inequality by the Acemoglu effect and the wage neutrality of immigration by the same argument.

This paper introduces a search-theoretical model containing most of the empirical facts of the impact of immigration on local labour markets. We give a rationale which kind of immigration may have led to the proposed effect of Lewis (2003, 2004) thus including a possible technology adaption effect of immigration (the Acemoglu-effect). We show that only a specific combination of quantity and skills of immigrants may replicate the empirical Lewis' observations. We combine this unskill biased technological change with an exogenous skill biased technological change and thus show how wage inequality evolved in the same way over local labour markets – despite of massive inflows of immigrants in certain local labour marktets. Therefore we give a comprehensive rationale for the wage inequality development for the US including skill biased technological change and immigration. In regions with high immigration rates such as Los Angeles, firms have larger incentives to offer vacancies for low-skilled workers with an increasing number of immigrants because this lowers vacancy costs. But if immigrants have lower educational attainments, firms have lower incentives to offer low-skilled vacancies. We show that both effects exactly compensate each other that we can replicate the empirical results of Lewis (2003, 2004).

Our paper has two additional features. First, we give an alternative indicator for unskill biased technological change (Lewis uses the on-the-job computer use); in our case, the number of vacancies in the low-skilled sector is higher in local labour markets with high immigration rates.[2] Second, we analyse possible out-migration of native workers from one to the other local labour markets which is one of the aforementioned absorbing effects. Most importantly, Lewis does not include native out-migration in his analysis why we may give an indication of a further compensating or magnifiying effect due to native out-migration.

[2]This applies especially for labour markets with a good data on vacancies as, e.g., Germany.

Relying on a combination of the frameworks of Albrecht and Vroman (2002) and Lumpe and Weigert (2007), we model an economy with two local labour markets. On the one hand, Los Angeles features high- and low-skilled native workers, high inflows of immigrants, exogenous skill biased technological change and unemployment. On the other hand, Pittsburgh has the same characteristics as Los Angeles except for immigration. Accounting for typical characteristics of the immigrant population of the US, we model immigrants as low-skilled having a positive probability of returning home (cf. Borjas, 1994). Due to this last feature, the job destruction rate of immigrants is higher implying that immigrants both earn lower wages and have higher unemployment rates than low-skilled natives.[3]

In both local labour markets, high-skilled natives may apply for high-skilled or low-skilled jobs. Low-skilled native workers and immigrants are limited to low-skilled jobs. As Albrecht and Vroman (2002), we get two kind of equilibria: a cross-skill matching equilibrium where high-skilled worker also take low-skilled jobs and an ex post segmentation equilibrium which has separated labour markets. We concentrate in general on the cross-skill matching equilibrium as we find it more realistic. In this setting, we may show the results of Lewis (2003, 2004) which indicate an offsetting effect of low-skilled immigration for the technology choice of firms. An increasing number of low-skilled workers (native and immigrant) increases incentives of the firms to create more vacancies resulting in higher wages for low-skilled workers. Once immigrants are lower skilled than native low-skilled workers (and thus the average skill endowment of a low-skilled worker falls), incentives to create more vacancies falls resulting in lower wages of low-skilled workers. If both effects exactly compensate each other, the results of Lewis (2003, 2004) are a special case of our model.

The present paper is related to a number of contributions in the literature. Obviously, we refer to a large empirical literature on the impact of immigration on wages, wage inequality and employment. There are mainly three conflicting results of this literature: (i) the existing immigration has a negative impact on native wages/employment (cf. Borjas, 2003, 2005) and wage inequality (cf. Borjas et al., 1996, 1997), (ii) the existing immigration has a negilible impact on wages/employment (cf. Card, 2001, 2005) and wage inequality (cf. Lewis, 2003, 2004) and (iii) immigration has a positive impact on wages/employment (cf. Ottaviano and Peri, 2005; Peri, 2007). Most of the literature, as well for other countries than the US, confirm the second result. We replicate in our

[3]This kind of discrimination is adapted from Mueller (2003).

model the structure of these models, local labour markets, and points of criticism on this method like, for example, native out-migration.

Depending on the substitubility or complementarity of immigrants, most of the theoretical models would predict a negative wage effect on low-skilled native worker (cf. Borjas, 1995, 1999). These findings are usually robust to different labour market institutions (cf. Schmidt et al. (1994); Fuest and Thum (2000); Kemnitz (2006)). Our model differs from these models (i) in the introduction of local labour markets, (ii) the analysis of out-migration and (iii) in the introduction of search frictions. Some articles have already analysed migration in a search theoretic context. In difference to our approach, these models focus mainly on migration patterns and welfare effects in a two-country setting (cf. Ortega, 2000; Sasaki, 2007).

Finally, we introduce the same effects indicated by the literature on skill biased technological change (cf. Acemoglu, 1998, 2002, 2003; Beaudry and Green, 2003): the technology of local firms responds to changes in local skill mixes caused by low-skilled immigration rather than relative wages. We rely on the model of Albrecht and Vroman (2002) which we use as benchmark labour market (meaning without immigration) because it offers the possibility to examine changes in the skill mix of labour supply caused by skill biased technological change or low-skilled immigration.

The remainder of the paper is structured as follows: in section 4.2 we present the basic structure of the model. In section 4.3 we derive both the cros skill matching and the ex post segmentation equilibrium. In section 4.4 we analyse the comparative static effects of the model and show the results of a numerical simulation of the model. Section 4.5 concludes.

4.2 Basic Model

In our model, we have two local labour markets: Pittsburgh has no immigration but skill biased technological change and is modelled according to Albrecht and Vroman (2002). Los Angeles has inflows of low-skilled immigrants and is a combination of the frameworks Albrecht and Vroman (2002) and Lumpe and Weigert (2007).

4.2.1 Households

We develop an equilibrium matching model of the Diamond-Mortensen-Pissarides. We have an economy with two cities – Los Angeles and Pittsburgh. Both cities are populated by a mass one of identical risk-neutral native workers $N = 1$. Los Angeles also experiences immigration $I > 0$ implying that the total population of the Los Angeles labour market is $1 + I$. There is no immigration in Pittsburgh. We have two types of native workers in both labour markets: low-skilled workers with labour market productivity z_L, and high-skilled workers with labour market productivity z_H.[4] We assume throughout $z_H > z_L$. Immigrants enter LA labour market with skill level $z_I \leq z_L$. In LA, low-skilled native workers constitue part π of the native population and high-skilled worker $1 - \pi$, respectively. Immigrants enter a labour market at rate $\mu > 0$ and leave the labour market due to return migration to their home country at rate $r > 0$. The steady-state number of immigrants in the Los Angeles labour market is $I = \mu/r$. Both, native and immigrant workers start their working life in the unemployment pool. We abstract from on-the-job search.

4.2.2 Matching

We follow Albrecht and Vroman (2002), and assume that high-skilled jobs can only be done by high-skilled natives but low-skilled jobs can be done by all three types of workers. Thus, labour markets are not fully separated. Matching is the same in both labour markets. We denote the number of unemployed workers by u and the number of vacancies by v. Labour market tightness is measured by $\theta = v/u$. The random process by which vacancies and unemployed workers find each other is represented by a matching function: $m(u, v) > 0$ with $u, v > 0$. The matching function denotes the number of matched vacancies and workers per unit of time.[5] The application arrival rate for vacant jobs $q(\theta)$ can then be written as: $q(\theta) = m(u, v)/v = m(1/\theta, 1)$ with $q'(\theta) < 0$ and $\lim_{\theta \to 0} q(\theta) = \infty$. The fraction of unemployed low-skilled workers is γ and for high-skilled workers $1 - \gamma$, respectively. The effective arrival rate for high-skilled vacancies is therefore $(1 - \gamma)q(\theta)$. In low-skilled unemployment, there is another probability η by

[4] Throughout the paper subscript H denotes high-skilled natives, L low-skilled natives and subscript I denotes immigrants.

[5] The matching function $m(u, v)$ is assumed to be twice continuously differentiable, homogeneous of degree one and exhibits the following properties: $m(0, v) = m(u, 0) = 0$, $\partial m/\partial u$, $\partial m/\partial v > 0$, $\partial^2 m/\partial u^2, \partial^2 m/\partial v^2 < 0$ and $\partial^2 m/\partial u \partial v > 0$. Relying on empirical estimations (as, e.g., Petrongolo (2001)), the constant returns to scale assumption of the matching function is plausible.

which low-skilled workers are either immigrants or natives. Thus, the final application rate in the low sector is $\eta\gamma q(\theta)$ for immigrants and $(1-\eta)\gamma q(\theta)$ for native low-skilled workers.

An unemployed worker meets a vacant job at the rate $p(\theta) = m(u,v)/u = \theta q(\theta)$ with $p'(\theta) > 0$ and $\lim_{\theta\to 0} p(\theta) = 0$. The fraction of low-skilled vacancies is denoted by ϕ giving the effective arrival rate for low-skilled workers as $\phi p(\theta)$. The effective arrival rate for high-skilled jobs is $(1-\phi)p(\theta)$. Native low-skilled workers and immigrants meet a vacant job at the same rate. Potential employers cannot directly search either a native low-skilled or immigrant worker. Whether it is a native low-skilled or an immigrant will be revealed when a firm and a worker meet. Thus, we have not included ex ante discrimination.

Filled jobs cost the wage $w(z,y)$ and a fixed cost k. They are destroyed by some exogenous rate s. Vacant jobs incur search costs k at each instant of time and have a minimum skill requirement. When the vacancy will be filled, it will produce ouput according to the following production technology:

$$f(z_i,y) = \begin{cases} y & if \quad z_i \geq y \\ 0 & if \quad z_i < y \end{cases}, \quad i = (H,L,I).$$

4.2.3 *Value Functions*

All individuals and firms discount future payments at the common rate ρ. We denote the expected value of unemployment by $U(z_i), \quad i = (H,L,I)$ and the expected present value of employment by $W(z_i,y), \quad (i = H,L,I)$. An unemployed worker receives the instantaneous unemployment benefit b, and will meet a vacant job at rate $\phi p(\theta)$, thereby swapping the value of unemployment $U(\bullet)$ with the value of employment $W(\bullet)$. Thus, the flow value of low-skilled unemployment is given by:

$$\rho U(z_i) = b + \phi p(\theta)[W(z_i,z_L) - U(z_i)], \quad i = (L,I). \tag{4.1}$$

The high-skilled worker may occupy either a high-skilled job (with rate $(1-\phi)p(\theta)$) or a low-skilled job (with rate $\phi p(\theta)$). For low-skilled workers arrive only low-skilled jobs. The flow value of a native high-skilled unemployment is given by:

$$\rho U(z_H) = b + p(\theta)\{\phi \max[W(z_H,z_L) - U(z_H),0] + (1-\phi)[W(z_H,z_H) - U(z_H)]\}. \tag{4.2}$$

While being employed a worker receives instantaneously wage $w(z_i, y)$. The job is expected to be closed at rate s and the worker enters the unemployment pool at that rate. The flow value of an employed worker can be written as:

$$\rho W(z_i, y) = w(z_i, y) + s[U(z_i) - W(z_i, y)], \quad i = (H, L, I). \tag{4.3}$$

We look at the expected present value of firms, which are either producing or searching for a worker. Let $V(z_i)$ and $J(z_i, y)$ be the expected present value of a vacant and a filled job, respectively. The flow value of a producing firm is given by:

$$\rho J(z_i, y) = y - w(z_i, y) - k + s[V(y) - J(z_i, y)], \quad i = (L, I). \tag{4.4}$$

The flow value of a filled job consists of the flow profits of a match $y - w(z, y) - k$ and the potential loss caused by the destruction of the job. The flow value of a high-skilled native vacancy can be written as:

$$\rho V(z_H) = -k + (1 - \gamma) q(\theta)[J(z_H, z_H) - V(z_H)], \tag{4.5}$$

and consists of the flow costs of searching k and the potential change from a vacant to a productive job. For the derivation of the flow value of a low-skilled vacancy, $\rho V(z_L)$, it is important that ex ante a firm does not know whether it will produce with a native or an immigrant worker. Any firm offering a vacant low-skilled job considers the expected present value of a filled job. The flow value of a vacant low-skilled job can then be written as:

$$\begin{aligned} \rho V(z_L) = \quad & -k + q(\theta)\{\eta(\theta)\gamma\left[J(a_I, a_L) - V(a_L)\right] \\ & +(1 - \eta(\theta))\gamma\left[J(a_L, a_L) - V(a_L)\right] \\ & +(1 - \gamma)\max\left[J(a_H, a_L) - V(a_H), 0\right]\}. \end{aligned} \tag{4.6}$$

where the first and the second part of (4.6) show the probability that the low-skilled vacancy is filled by an immigrant or a low-skilled native and the third part shows the arrival of a high-skilled native.

The present model contains Albrecht and Vroman (2002) and Lumpe and Weigert (2007) as special cases. If we abstract from immigration ($\mu = 0$), we are back in the model of Albrecht and Vroman. This case will serve as Pittsburgh labour market and thus is as benchmark to the Los Angeles labour market. If we abstract from high-skilled

labour ($\gamma = 1$), we get the model of Lumpe and Weigert with an exogenous and constant educational attainment of native workers.

4.2.4 Wage setting

The wage setting between workers and firms follows a Nash bargaining process. Free entry of firms generates an asset value of a vacancy of zero: $V(z_H) = V(z_L) = 0$. The wage is then a solution for the following optimisation problem:

$$w(z_i, y) = \arg\max \left(W(w) - U\right)^{\beta} \left(J(w) - V\right)^{1-\beta}, \quad i = (H, L, I), \tag{4.7}$$

where β is interpreted as the bargaining power of workers.[6] The wage setting function can be derived from (4.7) by inserting the free entry condition, (4.3) and (4.4):

$$w(z_i, y) = \beta(y - k) + (1 - \beta)\rho U(z_i), \quad i = H, L, I. \tag{4.8}$$

There are four different wages for Los Angeles. First, a low-skilled native worker on a low-skilled job earns wage $w_{LL} = w(z_L, z_L) = \beta(z_L - k) + (1 - \beta)\rho U(z_L)$. Second, a high-skilled native worker on a low-skilled vacancy: $w_{HL} = w(z_H, z_L) = \beta(z_L - k) + (1 - \beta)\rho U(z_H)$. Third, a high-skilled native worker on a high-skilled job: $w_{HH} = w(z_H, z_H) = \beta(z_H - k) + (1 - \beta)\rho U(z_H)$. These three wage setting equations apply for the Pittsburgh as well as for the Los Angeles labour market. But for the LA labour market, there is a fourth wage setting equation for immigrants on low-skilled jobs: $w_{IL} = w(z_I, z_L) = \beta(a_L - k) + (1 - \beta)(\rho + r)U(z_I)$. We summarise then wage setting for the labour markets in

Corollary 4.1. *High-skilled native workers earn always more than low-skilled native workers. Low-skilled native workers always earn more than immigrant workers (with less or the same amount of human capital):*

$$w_{HH} > w_{HL} > w_{LL} > w_{IL}.$$

[6] By using this formulation we assume that there is no difference in the bargaining power of natives and immigrants. Presumably the bargaining power of immigrants is lower compared to natives at the beginning of their working life in the host country and the same in the long run. However, taking this into account would not alter the results of the model qualitatively.

For future reference, we will give the closed form values for a filled job. These can be derived by substituting for the wage setting in (4.4) taking account of the free entry condition:

$$\begin{aligned} J_{ij} &= (1-\beta)(z_i - k - \rho U(z_j))/(\rho + s), \qquad i = j = H, L, \\ J_{ij} &= (1-\beta)(z_i - k - \rho U(z_j))/(\rho + s), \qquad i = L, \quad j = H, \\ J_{ij} &= (1-\beta)(z_i - k - \rho U(z_j))/(\rho + s + r), \quad i = L, \quad j = I. \end{aligned} \tag{4.9}$$

4.3 Equilibrium

We can differentiate two types of equilibria: first, the equilibrium where high-skilled worker take also low-skilled jobs. Following Albrecht and Vroman (2002), we call this equilibrium cross-skill matching equilibrium. The other type of equilibrium will be called ex post segmentation equilibrium as high-skilled workers do not take low-skilled jobs. Still, there exists the possibility of multiple equilibria.

4.3.1 Cross-skill matching

For a match to be formed in the cross-skill matching equilibrium, we maximise the Nash-product (cf. 4.7) and derive the following condition:

$$W(z, y) + J(z, y) \geq U(z) + V(y). \tag{4.10}$$

By inserting the expressions from (4.3) and (4.4) for $W(z, y)$ and $J(z, y)$ and using the free entry condition in (4.10), a match will be formed if

$$y - k \geq \rho U(z).$$

The condition holds if $z \geq y$.

Stocks

The flow equation $\dot{u}$ is the difference between inflows into unemployment and outflows from unemployment. With immigrants, low and high-skilled natives being in the pool of unemployed workers, we have three different flow equations. The flow equation for

low-skilled natives is $\dot{u}_L = s(\pi - (1-\eta)\gamma u) - \phi p(\theta)(1-\eta)\gamma u$, and the flow equation for high-skilled natives is $\dot{u}_H = s(1-\pi-(1-\gamma)u) - p(\theta)(1-\gamma)u$. For immigrants, the flow equation is $\dot{u}_I = \mu + s(I - \eta\gamma u) - \phi p(\theta)\eta\gamma u - r\eta\gamma u$. In steady state with $\dot{u}_i = 0$, we obtain that inflows equal outflows:

$$\mu + s(I - \eta\gamma u) = \phi p(\theta)\eta\gamma u + r\eta\gamma u, \tag{4.11}$$

$$s(\pi - (1-\eta)\gamma u) = \phi p(\theta)(1-\eta)\gamma u, \tag{4.12}$$

$$s(1-\pi-(1-\gamma)u) = p(\theta)(1-\gamma)u. \tag{4.13}$$

The steady state conditions can be solved for the unemployment rate u, the fraction of low-skilled vacancies ϕ and the rate of unemployed immigrants η:

$$u = \frac{s(1-\pi)}{(1-\gamma)(s+p(\theta))}, \tag{4.14}$$

$$\phi = \frac{\pi(1-\gamma)(s+p(\theta)) - s(1-\eta)\gamma(1-\pi)}{p(\theta)(1-\eta)\gamma(1-\pi)}, \tag{4.15}$$

$$\eta = \frac{(\mu/r)(s+r)(s+\phi p(\theta))}{\pi s(s+\phi p(\theta)+r) + (\mu/r)(s+r)(s+\phi p(\theta))}. \tag{4.16}$$

The properties for the Pittsburgh labour market are easily obtained by setting $\mu = 0$, which gives the same results as Albrecht and Vroman (2002).

Job creation condition

From the free-entry condition and equations (4.4), (4.5) and (4.6) and including (4.9), we can derive the job creation conditions (or equal-value conditions) for either a low-skilled job or a high-skilled job:

$$G_L(\theta,\gamma) \equiv \eta\gamma J_{IL} + (1-\eta)\gamma J_{LL} + (1-\gamma)J_{HL} = \frac{k}{q(\theta)}, \tag{4.17}$$

$$G_H(\theta,\gamma) \equiv (1-\gamma)J_{HH} = \frac{k}{q(\theta)}. \tag{4.18}$$

Equation (4.17) implies that the value of a low-skilled job taken by a high-skilled worker is strictly positive: $J_{HL} > 0$. Finally, we derive the closed form solution for the

expected present value of unemployment from (4.3), (4.1) and (4.2):

$$(\rho + r)U(z_I) = \frac{b(\rho + s + r) + \phi p(\theta)\beta(z_I - k)}{\rho + s + r + \phi p(\theta)\beta}, \tag{4.19}$$

$$\rho U(z_L) = \frac{b(\rho + s) + \phi p(\theta)\beta(z_L - k)}{\rho + s + \phi p(\theta)\beta}, \tag{4.20}$$

$$\rho U(z_H) = \frac{b(\rho + s) + [\phi z_L + (1 - \phi)z_H - k]p(\theta)\beta}{\rho + s + p(\theta)\beta}. \tag{4.21}$$

As in the standard matching models, the asset value of unemployment equals the weighted average of the asset values of being unemployed (asset value of unemployment benefits) and the asset value of being employed. Introducing these closed forms values for unemployment into the job creation conditions gives us the equilibrium values of the market tightness θ and the rate of unemployed low-skilled workers γ. Thus, these equilibrium values solve the flow equations for the stocks: the unemployment rate u, the rate of low-skilled vacancies ϕ and the number of immigrants in the low-skilled labour market η.

Proposition 4.1. *The cross-skill matching equilibrium is obtained by θ and γ and a vector of stock variables u, ϕ, and η that satisfy the job creation conditions $G_L(\theta, \gamma)$ and $G_H(\theta, \gamma)$, Nash bargaining, and the flow conditions for the stocks.*

4.3.2 Ex Post Segmentation Equilibrium

Now, high-skilled workers take only high-skilled vacancies – $z_L - k < \rho U(z_H)$ – and thus we have segmented labour markets of high and low-skilled jobs. We derive corresponding steady state conditions to the cross-skill matching equilibrium: there will be again three flow equations determining the unemployment rate, the rate of low-skilled vacancies and the number of immigrants. Finally, two job creation conditions determine the labour market tightness and the rate of unemployed low-skilled workers.

Stocks

For low-skilled natives and immigrants, the steady state condition for the inflows and outflows of unemployment (cf. (4.11) and (4.12)) stays the same but for high-skilled natives changes the condition as follows:

$$(1-\phi)p(\theta)(1-\gamma)u = s(1-\pi-(1-\gamma)u. \tag{4.22}$$

The equilibrium conditions for number of unemployed worker, the low-skilled vacancy rate and the rate of unemployed immigrants are as follows:

$$u = \frac{s(\gamma-\gamma\eta-2\pi\gamma+\pi\gamma\eta+\pi)}{(1-\gamma)\gamma(p(\theta)(1-\eta)+2s(1-\eta))}, \tag{4.23}$$

$$\phi = \frac{s\pi((1-\gamma)\gamma(1-\eta)(p(\theta)+2s))}{p(\theta)(1-\eta)\gamma s(\gamma-\gamma\eta-2\pi\gamma+\pi\gamma\eta+\pi)} - \frac{s}{p(\theta)}, \tag{4.24}$$

$$\eta = \frac{(\mu/r)(r+s)(s+\phi p(\theta))}{\pi s(s+\phi p(\theta)+r)+(\mu/r)(s+r)(s+\phi p(\theta))}. \tag{4.25}$$

Job creation condition

The asset value of unemployment for low-skilled natives does not change (cf. 4.1). Obviously, the asset value of unemployment for high-skilled workers changes because they match only with high-skilled vacancies:

$$\rho U(z_H) = \frac{b(\rho+s)+(1-\phi)p(\theta)\beta(z_H-k)}{\rho+s+(1-\phi)p(\theta)\beta}. \tag{4.26}$$

The job creation condition will be the same for the high-skilled filled jobs:

$$F_H(\theta,\gamma) \equiv (1-\gamma)J_{HH} = \frac{k}{q(\theta)}, \tag{4.27}$$

but it will change for the low-skilled filled jobs because of the absence of high-skilled workers:

$$F_L(\theta,\gamma) \equiv \eta\gamma J_{IL} + (1-\eta)\gamma J_{LL} = \frac{k}{q(\theta)}. \tag{4.28}$$

Proposition 4.2. *The ex post segmentation matching equilibrium is obtained by θ and γ and a vector of stock variables u, ϕ, and η that satisfy the job creation conditions $F_L(\theta,\gamma)$ and $F_H(\theta,\gamma)$, Nash bargaining, and the flow conditions for the stocks.*

4.4 Comparative Statics and Simulation

4.4.1 Comparative Statics

The comparative static results depend on the existing equilibria: we can examine effects of the movement from the cross-skill matching to the ex post segmentation equilibrium and vice versa or from the existing equilibrium to the same equilibrium. To follow the intuition of Lewis, we include the same kind of technological change which exists at Pittsburgh and at Los Angeles. Thus, we consider the following technology:

$$f(z,y) = \begin{cases} \alpha y & if \quad z \geq y \\ 0 & if \quad z < y \end{cases} .$$

By augmenting α for $z_H = y$, we spread the productivity gap between both type of jobs (low and high-skilled) which can be considered as exogenous skill biased technological change. The effects of this increase in z_H are twofold: first, high-skilled jobs will produce more output and the value of unemployment for high-skilled native workers increases: it is worthwile to wait longer for a high-skilled vacancy. Therefore firms which offer low-skilled jobs are worse off as they have to pay more for a high-skilled worker. The cross-skill matching equilibrium will move to a ex post segmentation equilibrium because native worker will not take any low-skilled jobs. With a constant θ and a rising γ ($\partial\theta/\partial z_H = 0, \partial\gamma/\partial z_H > 0$), the overall effects are an increasing number of unemployed workers $\partial u/\partial z_H > 0$ (because high-skilled worker wait longer for a job) and a decreasing rate of vacancies $\partial\phi/\partial z_H < 0$ (see (4.14) and (4.15)). This kind of technological change applies to both local labour markets – Pittsburgh and Los Angeles – because skill biased technological change has taken place over all local labour markets in the US.

Suppose now that we have at the same time low-skilled immigrants at Los Angeles. If these immigrants are even lower skilled than native low-skilled workers, the average productivity of a low-skilled job will decrease. This would spread the productivity gap between both jobs even more. Overall unemployment should rise more because low-skilled vacancies are even worse for firms and high-skilled worker will still have to be paid more. Focusing on mass migration of low-skilled workers (more low-skilled immigrants instead of lower skilled immigrants and thus an increasing μ), the effects will be rather different. Low-skilled vacancies will be more attractive due to the higher number of immigrants in the market which enlarges the unemployment value for immigrants and low-skilled natives and leads to higher wages of immigrants and low-skilled

natives. The labour market is therefore characterised by higher low-skilled vacancies, lower low-skilled unemployment and a declining wage inequality between and low and high-skilled natives.

Changing the type of equilibrium – from cross-skill matching to ex post segmentation equilibrium – the indirect effect of lower skilled immigrants and technological change on the value of a low-skilled vacancy decreases as we have not any high-skilled workers who take low-skilled jobs. This leads to rising θ and γ, but the effects on u and ϕ are ambigious. By the movement from the cross-skill matching to the ex post segmentation equilibrium, we expect a rise in unemployment because high-skilled workers have more high-skilled vacancies but losing low-skilled vacancies.

4.4.2 Numerical example

Pittsburgh

The following numerical example shall illustrate the theoretical discussion and will be calibrated for the US economy. The matching function is assumed to be of Cobb-Douglas type $m(u,v) = 2\sqrt{uv}$ which gives an arrival rate of $p(\theta) = 2\sqrt{\theta}$. Thus, the elasticity of the matching function is 0.5 (cf. Petrongolo and Pissarides (2001)). The bargaining power β is also set to 0.5 for the US which is in line with the estimates of Abowd and Allain (1996). For the values of the other exogenous variables, we choose values close to those applied by Albrecht and Vroman (2002): $s = 0.2$, $\rho = 0.05$, $b = 0.1$, $k = 0.3$. The job destruction rate is lower in our case because we have not included on-the-job search in our model.[7]

The baseline scenario has a cross-skill matching equilibrium. The overall unemployment rate is 0.086 per cent and about 70 per cent of these unemployed workers are low-skilled worker (see row 1 in table 4.1). This implies that most of the jobs in Pittsburgh are low skilled jobs. Thus, the wages for low-skilled workers and high-skilled workers on low-skilled jobs are nearly the same. Most of the vacancies are issued for the low-skilled sector due to relatively higher number of low-skilled workers in the labour market. For the labour market tightness, we get $\theta = 1.676$ implying a vacancy rate $v = 0.133$. The average duration of native unemployment is about 5 months ($12 \times (1/2.59) = 4.63$) whereas the average duration of a vacancy is about 8 months ($12 \times (1.676/2.59) = 7.76$).

[7] Shimer (2005) gives an annual job separation rate of 0.408. Petrongolo and Pissarides (2001) show that on-the-job changes represented about 20 per cent in the US to up to 40 per cent in the UK of total hires.

z_H	θ	$p(\theta)$	u	γ	ϕ	w_{LL}	w_{LH}	w_{HH}	ω
1.2	1.676	2.59	0.080	0.639	0.834	0.643	0.665	0.765	0.122
Technological Change									
1.25	1.676	2.59	0.086	0.666	0.732	0.637	0.680	0.804	0.167
1.3	1.676	2.59	0.092	0.688	0.657	0.632	0.695	0.845	0.213
1.35	1.790	2.68	0.144	0.607	0.391	0.601	–	0.936	0.335

Table 4.1: Skill biased technological change in Pittsburgh

($z_L = 1$, $\pi = 0.60$, $b = 0.1$, $\beta = 0.5$, $s = 0.2$, $k = 0.3$, $\rho = 0.05$)

With skill biased technological change (an increase in z_H), firms begin to offer more vacancies for high-skilled workers which shows the decrease of ϕ (the overall vacancy rate increases to $v = 0.1538$). With this increasing number of high-skilled vacancies, the value of unemployment for high-skilled workers increases. Therefore the unemployment rate of low-skilled workers increases and wages for low-skilled workers fall while wages for high-skilled workers increase. The increase of high-skilled wages comes either from the better bargaining position of high-skilled workers (through the higher value of unemployment: U_H increases from 12.61 to 13.78) and the higher output of a match (through the higher educational attainment). Still, the overall unemployment rate increases slightly due to the worsening of the vacancy rate for low-skilled workers. Finally we get increasing wage inequality which corresponds to the analysis of Acemoglu (1998). In the last row of table 4.1, we show the case of a change in the type of equilibrium.

With an increase to $z_H = 1.35$, the cross-skill matching equilibrium changes into an ex post segmentation equilibrium. Now, the labour markets for low and high-skilled workers are separated and thus the overall unemployment rate increases sharply through more unemployment of high-skilled workers. They wait now longer for a high-skilled vacancy to come because their value of unemployment increases largely with their higher wage on high-skilled vacancies ($U_H = 16.54$). The vacancy rate also increases sharply ($v = 0.241$) but mostly for high-skilled workers as the decline in ϕ shows.

Los Angeles

We will start with a relatively modest number of immigrants in the LA labour market. The steady-state stock of immigrants $I = \mu/\delta_I = 0.3$ meaning that $\sim 23\%$ of the total population are immigrants. This is a comparably low number of immigrants: in Dade

county in the US, 40 per cent of the total population are immigrants. We then raise the number of immigrants in the labour market up to 28 per cent of the total population. In the last row of table 4.2 and table 4.3, we decrease the labour market productivity of immigrants from $z_I = 0.95$ to $z_I = 0.9$. This is line with the empirical studies which show that the educational endowment of immigrants has decreased for the last decades (cf. Borjas (1994)). Most of values are choosen to replicate the empirical result of the same wage inequality in both local labour markets. All the remaining exogenous parameters are set to the same values as for Pittsburgh.

z_H	z_I	μ	δ_I	η	θ	u	γ	ϕ
1.20	0.950	0.015	0.05	0.477	1.811	0.107	0.612	0.780
Technological Change & Immigration								
1.25	0.950	0.020	0.05	0.550	1.834	0.119	0.655	0.766
1.30	0.900	0.020	0.05	0.550	2.021	0.118	0.666	0.724

Table 4.2: Skill biased technological change and immigration in Los Angeles

($z_L = 1$, $\pi = 0.4$, $b = 0.1$, $\beta = 0.5$, $s = 0.2$, $k = 0.3$, $\rho = 0.05$)

z_H	z_I	μ	δ_I	w_{IL}	w_{LL}	w_{LH}	w_{HH}	ω
1.20	0.950	0.015	0.05	0.615	0.643	0.670	0.770	0.127
Technological Change & Immigration								
1.25	0.950	0.020	0.05	0.613	0.642	0.678	0.803	0.161
1.30	0.900	0.020	0.05	0.594	0.641	0.690	0.840	0.199

Table 4.3: Skill biased technological change and immigration in Los Angeles

($z_L = 1$, $\pi = 0.4$, $b = 0.1$, $\beta = 0.5$, $s = 0.2$, $k = 0.3$, $\rho = 0.05$)

The first table shows the values for η, θ, u, γ, and ϕ; while the second table shows the different wages and the wage premium. In the baseline scenario, the labour market tightness is $\theta^E = 1.811$ which is slightly higher to the labour market tightness of Pittsburgh. The vacany rate is also slightly higher with $v = 0.19$. The average duration of native unemployment is about 5 months ($12 \times (1/2.69) = 4.46$), which is also close to the baseline scenario of the Pittsburgh labour market. The average duration of a vacancy is about 8 months ($12 \times (1.81/2.69) = 8.07$). As for Pittsburgh, including on-the-job search would provide us with a lower average duration of a vacancy.

We can clearly show that, even with massive inflows of low-skilled immigrants, we may have the same wage premium ($\omega = w_{HH} - w_{LL}$) in Los Angeles and Pittsburgh. In

the second row of table 4.2 and 4.3, we only have augmented the number of immigrants in Los Angeles (from 23 per cent to 28 per cent); while in the third row of table 4.2 and 4.3, we have decreased the skill endowment of immigrants z_I (from 0.95 to 0.90). However, the wage premium (ω) remains the same over both local labour markets: for example, 0.127 in Pittsburgh versus 0.121 in Los Angeles. This is possible because there are conflicting incentives for firms to offer low-skilled vacancies. On the one hand, a higher number of low-skilled workers in the labour markets induces firms to invest more in low-skilled vacancies due to the lower vacancy costs. On the other hand, lower skill endowments of immigrants decreases the productivity of a low-skilled job and thus decreases incentives to invest in low-skilled vacancies. Therefore, wages of low-skilled native workers are slightly lower in Los Angeles than in Pittsburgh. Obviously, immigrant wages are even lower because of the higher probability to leave the match. And finally, skill biased technological change leads to nearly the same increases in wages for high-skilled workers in both labour markets. Interestingly, only low-skilled immigration in combination with high inflows of immigrants will result in a constant wage premium over local labour markets. If we would admit fewer low-skilled immigrants, wages of low-skilled natives would decrease. Furthermore, only admitting high-skilled immigrants would lead to rising wage inequality. The higher number of low-skilled vacancies ϕ in Los Angeles shows the unskill biased technological change in this local labour market.

Lewis (2003) measures indirectly the technology adoption of firms through the use of computers in the different local labour markets. We may now propose different indirect measures of this technology adoption. For example, the measure of low-skilled vacancies ϕ should be higher and decrease slower as z_H increases in Los Angeles than in Pittsburgh.

4.4.3 Extension: native out-migration

Most of the empirical studies control for native out-migration from local labour markets which may offset the wage effects of immigration. Interestingly, these empirical studies are also controversial with respect to the existence of out-migration: Card and DiNardo (2000) and Card (2001) find no out-migration of natives caused by immigration but Borjas (2005) explains an important part of the non-existing effect of immigration on local labour markets with native out-migration. However, we will discuss if native out-migration may reverse our results from the previous sections.

Native workers would leave their local labour market if their value of unemployment differ over both local labour markets. The indifference condition for both skill groups is: $U_i^{LA} = U_i^{Pi}, \quad i = L, H$. Thus, we will compare the values of unemployment for high- and low-skilled native workers in both local labour markets (for comparable scenarios of table 4.1 and table 4.3:

Pittsburgh		Los Angeles	
U_H	U_L	U_H	U_L
12.61	11.74	12.80	11.73
13.18	11.49	13.11	11.66
13.78	11.27	13.61	11.61

Table 4.4: Values of unemployment for high- and low skilled native workers

The values of unemployment of low skilled workers are nearly similar over both labour markets so that there is no native out-migration of low-skilled worker. The value of unemployment for high-skilled native workers is higher in Los Angeles than in Pittsburgh. If therefore high-skilled natives would move from Los Angeles to Pittsburgh, wage inequality would increase (decrease) in Pittsburgh (Los Angeles). Thus, in Pittsburgh, we would get segmented labour markets whereas in Los Angeles, we would have cross-skill matching and high rate of low-skilled jobs. However, the difference of the values of unemployment in both labour markets would vanish if we consider moving costs.

4.5 Conclusion

We model two local labour markets (Pittsburgh and Los Angeles) where both are characterised by skill biased technological change, equilibrium unemployment and not perfectly segmented labour markets of high- and low skilled native workers. Only one of these labour markets has massive inflows of immigrants (Los Angeles). This allows us to introduce unskill biased technological change in the local labour market with immigration. Because of a positive probability of returning to their home countries, immigrants receive lower wages and have a higher unemployment rate compared to natives. We can show that both local labour markets will have the same relative wage although Los Angeles had massive inflows of immigration. This replicates the empirical results of Lewis (2003) but also shows that these results are due to a special coincidence of number and skill endowments of immigrants. The effects of an increase in the number of immigrants

and a decrease in the skill endowments of immigrants leads to unskill biased technological change but does not result in a change in relative wages at Los Angeles compared to Pittsburgh. Furthermore, we discuss the implications of our results for native outmigration; another heatedly debated issue of empirical studies.

4.A Appendix

4.B Appendix

4.B.1 Derivation of (4.10) and (4.8)

Introducing the equations for $W(\bullet)$ and $J(\bullet)$ and the free-entry condition in (4.10) gives:

$$W(z,y) + J(z,y) \geq U(z) + V(y),$$

$$\frac{w(z,y) + sU(a)}{\rho + s} + \frac{y - w(z,y) - k}{\rho + s} \geq U(z),$$

$$y - k \geq \rho U(z).$$

For immigrants, the depreciation rate is $\rho + \delta_I$ instead of ρ. Introducing the equations for $W(\bullet)$ and $J(\bullet)$ and the free-entry condition in (4.7) gives:

$$(1-\beta)W(z,y) = \beta J(z,y) + (1-\beta)U(z),$$

$$(1-\beta)\left(\frac{w(z,y) + sU(z)}{\rho + s}\right) = \beta\left(\frac{y - w(z,y) - k}{\rho + s}\right) + (1-\beta)U(a),$$

$$(1-\beta)(w(z,y) + sU(z)) = \beta(y - w(z,y) - k) + (1-\beta)(\rho + s)U(z),$$

$$\beta(y - w(z,y) - k) + (1-\beta)[(\rho + s)U(z) - w(z,y) - sU(z)] = 0,$$

$$w(z,y) = \beta(y-k) + (1-\beta)\rho U(z).$$

4.B.2 Derivation of the steady-state values of u, ϕ, and η for cross-skill matching

The steady-state value of u can be derived as follows:

$$p(\theta)(1-\gamma)u = s(1 - \pi - (1-\gamma)u),$$

$$p(\theta)(1-\gamma)u + s(1-\gamma)u = s(1-\pi),$$

$$(1-\gamma)(p(\theta) + s)u = s(1-\pi),$$

$$u = \frac{s(1-\pi)}{(1-\gamma)(p(\theta) + s)}.$$

The steady-state value of ϕ can be derived by (4.12)/(4.13):

$$\phi\frac{(1-\eta)\gamma}{(1-\gamma)} = \frac{\pi-\gamma(1-\eta)u}{(1-\pi)-(1-\gamma)u},$$

$$\phi = \frac{(1-\gamma)(\pi-\gamma(1-\eta)u)}{(1-\eta)\gamma((1-\pi)-(1-\gamma)u)}.$$

By inserting of (4.14), we get:

$$\phi = \frac{(1-\gamma)\pi-\gamma(1-\eta)(s(1-\pi))/(p(\theta)+s)}{(1-\eta)\gamma(1-\pi)-\gamma(1-\eta)(s(1-\pi))/(p(\theta)+s)},$$

$$\phi = \frac{(1-\gamma)\pi(p(\theta)+s)-\gamma(1-\eta)(s(1-\pi))}{(1-\eta)\gamma(1-\pi)(p(\theta)}.$$

The steady-state value of η can be derived from (4.12) and (4.11). By converting (4.12) and (4.11), we get:

$$(1-\eta)\gamma u = s\pi/(\phi p(\theta)+s),$$

and

$$\eta\gamma u = I(r+s)/(\phi p(\theta)+s+r).$$

Dividing both expressions gives:

$$\frac{1-\eta}{\eta} = \frac{s\pi(\phi p(\theta)+s+r)}{I(r+s)(\phi p(\theta)+s)},$$

$$\eta = \frac{I(r+s)(\phi p(\theta)+s)}{s\pi(\phi p(\theta)+s+r)+I(r+s)(\phi p(\theta)+s)}.$$

4.B.3 Rewriting the job creation condition

Taking (4.18) and including (4.21):

$$\frac{z_H-k-\left(\frac{b(\rho+s)+p(\theta)\beta[\phi z_L+(1-\phi)z_H-k]}{\rho+s+p(\theta)\beta}\right)}{\rho+s} = \frac{k}{(1-\beta)(1-\gamma)q(\theta)},$$

$$\left(\frac{(\rho+s+p(\theta)\beta)[z_H-k]-b(\rho+s)-p(\theta)\beta[\phi z_L+(1-\phi)z_H-k]}{\rho+s+p(\theta)\beta}\right)$$

$$= \frac{k(\rho+s)}{(1-\beta)(1-\gamma)q(\theta)},$$

$$\left(\frac{[(\rho+s)(z_H-k-b)-p(\theta)\beta(z_H-k)-p(\theta)\beta\phi(z_L-z_H)+p(\theta)\beta(z_H-k)]}{\rho+s+p(\theta)\beta}\right)$$

$$= \frac{k(\rho+s)}{(1-\beta)(1-\gamma)q(\theta)},$$

$$(1-\beta)\left(\frac{[(\rho+s)(z_H-k-b)+p(\theta)\beta\phi(z_H-z_L)]}{\rho+s+p(\theta)\beta}\right) = \frac{k(\rho+s)}{(1-\gamma)q(\theta)},$$

$$\frac{q(\theta)}{(\rho+s)}\frac{(1-\beta)(1-\gamma)\left[(\rho+s)(z_H-k-b)+p(\theta)\beta\phi(z_H-z_L)\right]}{(\rho+s+p(\theta)\beta)} = k.$$

4.B.4 Derivation of the steady-state values of u and ϕ for ex post segmentation

From (4.12), we get $\phi = s(\pi-\gamma(1-\eta)u)/p(\theta)(1-\eta)\gamma u$ and insert this expression into (4.22):

$$(1-\left(\frac{s(\pi-\gamma(1-\eta)u)}{p(\theta)(1-\eta)\gamma u}\right))p(\theta)(1-\gamma)u = s(1-\pi-(1-\gamma)u),$$

$$[(p(\theta)(1-\eta)\gamma u+s(1-\eta)\gamma u-s\pi](1-\gamma)+s(1-\eta)\gamma(1-\gamma)u = (s-s\pi)(1-\eta)\gamma,$$

$$[p(\theta)(1-\eta)\gamma u+2s(1-\eta)\gamma u](1-\gamma) = (s-s\pi)(1-\eta)\gamma+s\pi(1-\gamma),$$

$$u = \frac{s(\gamma-\gamma\eta-2\pi\gamma+\pi\gamma\eta+\pi)}{[p(\theta)+2s](1-\eta)\gamma(1-\gamma)}.$$

Inserting of (4.23) in $\phi = s(\pi-\gamma(1-\eta)u)/p(\theta)(1-\eta)\gamma u$:

$$\phi = \frac{s(\pi-\gamma(1-\eta)u)}{p(\theta)(1-\eta)\gamma u} = \frac{s\pi}{p(\theta)(1-\eta)\gamma u}-\frac{s}{p(\theta)},$$

$$\phi = \frac{s\pi((1-\gamma)\gamma(1-\eta)(p(\theta)+2s))}{p(\theta)(1-\eta)\gamma s(\gamma-\gamma\eta-2\pi\gamma+\pi\gamma\eta+\pi)}-\frac{s}{p(\theta)}.$$

The derivation of the expression for η is the same as for the cross-skill matching case.

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Erklärung

Ich erkläre hiermit, dass ich die vorliegende Arbeit mit dem Thema

Immigration, unemployment, and human-capital acquisition

ohne unzulässige Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Die aus anderen Quellen direkt oder indirekt übernommenen Daten und Konzepte sind unter Angabe der Quelle gekennzeichnet. Weitere Personen, insbesondere Promotionsberater, waren an der inhaltlich materiellen Erstellung dieser Arbeit nicht beteiligt. Die Arbeit wurde bisher weder im In- noch im Ausland in gleicher oder ähnlicher Form einer anderen Prüfungsbehörde vorgelegt.

Frankfurt, den 29. Juni 2008

(Christian Lumpe)

Abgrenzung

Kapitel 2 entstammt einer gemeinsamen Arbeit mit Herrn Benjamin Weigert (Justus-Liebig-Universität Gießen). Die individuelle Leistung im Rahmen dieser Arbeit gliedert sich wie folgt:

i. Introduction:
   50% Lumpe / 50% Weigert
ii. The model:
   50% Lumpe / 50% Weigert
iii. Immigration and the labour market:
   50% Lumpe / 50% Weigert
iv. Conclusions:
   50% Lumpe / 50% Weigert

Kapitel 3 entstammt einer gemeinsamen Arbeit mit Herrn Benjamin Weigert (Justus-Liebig-Universität Gießen). Die individuelle Leistung im Rahmen dieser Arbeit gliedert sich wie folgt:

i. Introduction:
   50% Lumpe / 50% Weigert
ii. Basic model:
   50% Lumpe / 50% Weigert
iii. Educational decisions and equilibrium:
   50% Lumpe / 50% Weigert
iv. Efficiency and labour market policies:
   50% Lumpe / 50% Weigert
v. Numerical example:
   50% Lumpe / 50% Weigert
vi. Extension:
   50% Lumpe / 50% Weigert
vii. Conclusions:
   50% Lumpe / 50% Weigert

Ich versichere hiermit, dass ich die Kapitel 1 und 4 der vorliegenden Arbeit ohne Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe.

Frankfurt, den 29. Juni 2008

(Christian Lumpe)