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Essays on the Effects of Migration and Demographic Factors on Labor Markets and Human Capital Accumulation

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To my husband my strength.

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Contents

Chapter 1

Introduction

This thesis examines the effects of international migration and social norms on human capital formation, local labor markets and workers' welfare. Migration not only affects the countries of destinations but it also has consequences for the source countries. This thesis looks at the consequences of inflow(outflow) of workers to(from) a country in terms of changes in human capital, wages, unemployment rate and informal employment rate. It then analyzes the implications of these changes for the welfare of residents. The thesis also show that human capital formation is not only affected by international migration but local social norms within a country also play a very important role in this regard.

The first chapter focuses on the long-term effects of immigration on labor market outcomes and welfare of natives in Germany using a search and matching framework. Existing literature is focused on estimating wage effects of immigration and is mostly based on the assumption of a competitive labor market with the marginal pricing of labor. This approach doesn't take into account the bargaining nature of wage-setting in Germany and high propensity of vertical skill mismatch, implying that labor market frictions may be an important transmission channel when analyzing the effect of immigration. Moreover, there remain open questions concerning the general equilibrium effects and welfare changes in response to immigration. This study addresses these issues by explicitly distinguishing between the tradable manufactured goods and non-tradable services. Hence it decomposes the total effect of immigration into the separate contributions of a rise in labor supply, endogenous response in the creation of vacancies, price-setting in the non-tradable sector and the redistributive fiscal policy. Overall, the study concludes that accounting for changes in the aggregate supply and demand of the non-tradable good generates additional welfare gains from immigration which were not considered in the existing literature.

The second chapter proposes that international migration also has implications for source countries. It analyzes the effect of emigration of high-skilled workers on labor market, inequality, informality and human capital formation in source countries. It shows that perfectly competitive framework as assumed in the existing literature fails to explain the observed wage differential across formal and informal sectors. In perfectly competitive framework inequality remains unaffected by brain drain in presence of informality. It proposes an alternative Search-and-Matching model to study how the brain drain affects the welfare of those left behind, with or without positive spin-offs from emigration. Parametrizing the model on Sub-Saharan Africa, it produces estimates of the welfare and inequality effects of the brain drain for each sending country. The study concludes countries with better education technologies and better TFP in formal sector (relative to the informal sector) lose more from brain drain as they observe a higher inequality and bigger welfare loss.

The third chapter explores the effect of fertility norms on the tradeoff between the quantity and quality (investment in education of children made by mothers) of children in Pakistan. The existing literature so far does not quantify the effect of norms on quality. There is no data available on the quality of children for Pakistan so I use a strategy that allows to extract this information. First a quantity-quality model augmented with role of norms and childlessness is developed. The effect of fertility norms on quantity-quality trade-off is quantified by estimating an auxiliary econometric model. Using the facts from the econometric analysis the structural parameters of the theoretical model are identified. The theoretical model is used to simulate the quality of children in Pakistan. This chapter then gives information on fertility and corresponding quality of children in women belonging to different ethnic and education groups. This provides an idea of women's behaviour regarding investment in the education of their children. This information can prove to be meaningful in assisting policy makers for the design of effective population/education policy. For example the study concludes that poor women are more responsive to wage changes in terms of investment in education relative to consumption expenditure. So, a wage policy that targets the less educated women can be helpful in improving children quality in these women. The study concludes that norms influence the effect of economic development on quantity-quality trade-off.

Chapter 2

General Equilibrium Effects of Immigration in Germany: Search and Matching Approach

In this study we develop and calibrate a search and matching model of the German labour market and analyze the impact a 25% increase in immigration observed in the period 2012-2016. Our model has two production sectors (tradable manufacturing and non-tradable services), two skill groups and two ethnic groups of workers (natives and immigrants). Moreover, we allow for the possibility of vertical skill mismatch of high skill workers, endogenous price setting in the non-tradable sector and fiscal redistribution policy. We find that immigrant workers are underrepresented in services compared to manufacturing, so there is only a moderate output increase in the production of services in response to immigration. This output increase is insufficient to cover the associated higher demand for services, which generates a higher price in this sector and stimulates job creation. Workers in services gain welfare but there is a negative effect on the real income of workers in manufacturing. Our results show that recent immigration to Germany, including refugees, has a moderate negative effect on the welfare of low skill workers in manufacturing (-1.2%), but all other worker groups are gaining from immigration, with high skill service employees gaining the most (+6.3%). The average effect of recent immigration after we account for changes in the fiscal budget is estimated at +3.0% but there is larger inequality in the post-immigration steady state.

2.1 Introduction

This study investigates the effect of immigration on the German labour market in a search and matching framework. We develop a detailed model of the German labour market with heterogeneous worker groups and calibrate it to match group-specific moments of empirical data in the year 2011. Based on this model we perform a theoretical experiment by increasing the stock of immigrants, adequate in size to the observed increase in the years 2012–2016, and quantify the economic impact on native workers and incumbent immigrants.

Existing literature is focused on estimating wage effects of immigration and is mostly based on the assumption of a competitive labour market with the marginal pricing of labour[1]. This approach doesn't take into account the bargaining nature of wage-setting in Germany and high propensity of vertical skill mismatch, implying that labour market frictions may be an important transmission channel when analyzing the effect of immigration, which is not captured by the neo-classical competitive market framework. Moreover, there remain open questions concerning the general equilibrium effects and welfare changes in response to immigration. Our study addresses these issues by explicitly distinguishing between the tradable manufactured goods and non-tradable services. Hence we are able to decompose the total effect of immigration into the separate contributions of a rise in labour supply, endogenous response in the creation of vacancies, price-setting in the non-tradable sector and the redistributive fiscal policy. To the best of our knowledge there is no other study for Germany that estimates these effects in a unified labour market framework with search frictions. To calibrate the model we use data from the German Socio-Economic Panel and aggregate macroeconomic indicators.

More specifically, we consider a labour market with two production sectors: tradable (manufacturing) and non-tradable (services). In both sectors high and low skill labour is employed in the production of output and combined together by means of a CES production function[2]. Thus there are four separate submarkets in our model depending on the sector and the skill level of workers. We use a search and matching framework to model endogenous job creation (vacancies) in each submarket following the approach of Pissarides (2000). Every worker can be a native or an immigrant, so there are eight heterogeneous worker groups in our model depending on the ethnic origin, skill level of the worker and the production sector. Native and immigrant workers apply for the same vacancies in each of the four submarkets, however, their employment chances, productivities and wages can be different. Wages are set by means of Nash-bargaining and reflect differences in productivities and outside opportunities of workers.

Low skill workers can be employed and producing output or unemployed and searching for low skill jobs. Unemployed high skill workers are simultaneously applying to high and low skill jobs and can be vertically mismatched in the sense of overeducation. We assume that mismatched high skill workers performing low skill jobs continue searching on-the-job and applying to vacancies with a high skill requirement. Our motivation to account for the occupational mismatch of high skill workers follows the argument of Dustmann and Preston (2012) and Dustmann et al. (2013) that high skill immigrant workers from developing countries are often downgraded when they enter the labour market of a developed receiving country. Moreover, immigrant workers experience higher rates of overeducation in Germany compared to native workers (see Salikutluk et al. (2016)). Accounting for the higher propensity of skill mismatch among immigrants allows us to capture the asymmetric effects of the recent low skill immigration on high skill native and incumbent immigrant workers.

Further, workers have homothetic preferences with a CES utility function and decide how to

[1] Exceptions include Chassamboulli and Palivos (2014) and Battisti, Felbermayr, Peri and Poutvaara (2014)

[2] In our benchmark calibration we use the Cobb-Douglas form as a limiting case of the CES, but in the extensions we also consider the elasticity of substitution between high and low skill workers larger than 1.

spend their income (wages or unemployment benefits) between consumption of goods and services. Given that Germany is an export oriented economy we assume that manufactured goods are traded on the international market and their price is exogenous to the model. In contrast, services are non-tradable, so their price is determined endogenously by equating the supply and demand. Thus we explicitly take into account that the inflow of new immigrants changes both the supply and demand for the non-tradable good (services) thereby influencing its price. Here we follow th approach of Altonji and Card (1991) who emphasize that "the arrival of new immigrants shifts the demand for city output and hence the demand functions for skilled and unskilled labour" (p. 203). Finally, we assume a balanced budget of the social planner, who collects income taxes, pays out unemployment benefits and distributes the remaining surplus as a lump-sum transfer to all workers.

We use data from the German-Socio Economic Panel, wave 2011, to calibrate group-specific wages, unemployment rates and mismatch rates. The data reveals that native workers are facing about 1.5% lower probability of unemployment and about 9% lower probability of overqualification than immigrant workers. Further, high skill workers earn about 50% more than low skill workers, however, most of this return (43%) is lost if high skill workers are mismatched and perform low skill jobs. Considering the sectoral perspective, we find that low skill immigrant workers are overrepresented in manufacturing jobs (12.6%) and underrepresented in service jobs (8.8%). One reason for this is that manufacturing is a low skill intensive sector and there is a higher fraction of the low skilled among immigrants compared to natives. Another reason could be a language disadvantage of immigrant workers in providing services. In order to calibrate the matching function for Germany we used aggregate data of the Federal Employment Agency (BA) for the period 2000-2017. We find that the average vacancy duration has almost tripled over this period from 35 to 100 days, reflecting a rising shortage of the workforce. Our estimate of the elasticity of the matching function (job-filling rate) is equal to 0.47 and is close to 0.5, which is often assumed in the search and matching literature.

Having performed the calibration we analyzed the implications of a 25% increase in immigration observed in Germany in the period 2012-2016. Even though reliable data on the skill composition of recent migrants is not available yet, a large fraction of refugees from low income countries indicates that the inflow of recent migrants is low-skill biased, so we focus on the case of low skill immigration. In this case we find that immigration leads to 1.2% higher aggregate welfare of incumbent workers in Germany. The primary reason for a positive effect is a higher internal demand for the non-tradable good (services). Given that immigrant workers are overrepresented in manufacturing jobs, a larger fraction of new immigrants finds jobs in manufacturing compared to services, so the relative increase in the supply of services is insufficient to match the relative increase in the demand. This leads to a higher price of services and a higher labour demand in this sector inducing higher wages and lower unemployment of both skill groups.

Further, we find that immigration raises a positive surplus of the public budget. We decompose this change into a direct and an indirect effect. First, low skill immigrant workers have low wages and high unemployment rates, so the direct effect of adding more low skill immigrants to the market reduces the positive surplus of the budget. Hence the direct effect of low skill immigration is negative. However, there is also an indirect general equilibrium effect: native and incumbent immigrant workers in the non-tradable sector (services) receive higher wages and their unemployment rate is lower. This leads to the fact that their tax contributions are higher and budget expenses on their unemployment benefits are lower. So the indirect effect of immigration on the budget surplus is positive and dominates the direct negative effect. Allowing for higher lump-sum transfers to restore the balance of the budget we report a total increase in welfare equal to 3%. This corresponds to the elasticity of immigration equal to $0.03/0.25 = 0.12$ and means that one percent increase in immigration leads 0.12% increase in average welfare. This estimate is somewhat larger than estimates provided by Battisti, Felbermayr, Peri and Poutvaara (2014) for Germany due to the fact that we explicitly account for price adjustment in the non-tradable sector. Moreover, the positive effect of immigration on public finances in Germany is not completely unexpected. For example, in his empirical research Bonin (2014) reports that a netto contribution of an average immigrant living in Germany in 2012 was about 3300 with the total contribution of all immigrants equal to 22 Bln. Dustmann and Frattini (2014) report similar results for the UK.

Considering the effect on different worker groups, we find that productivity of low skill workers falls, whereas the productivity of high skill workers increases in response to low skill immigration in line with the neoclassical tradition in Borjas (1999). The new result is that immigration puts an upward pressure on the price of services benefiting workers employed in this sector. However, a higher price index is harmful for workers employed in manufacturing since their real income is lower. So there is an asymmetric effect on the two sectors. Whereas manufacturing workers are worse off due to the fact that services become more expensive, workers employed in services are gaining since higher prices stimulate job creation in their sector. Overall, low skill workers employed in manufacturing face lower wages and higher unemployment. Combined with a higher price of services this leads to the change in welfare of these workers equal to -3.3% prior to the budget adjustment and -1.2% afterwards. High skill workers employed in manufacturing gain in terms of productivity, which leads to higher wages and lower unemployment, but this positive effect is mitigated by higher prices, so the change in their welfare is equal to -0.3% prior to the budget adjustment and $+1.3\%$ afterwards. Low skill workers employed in services gain higher wages and lower unemployment, which is due to the positive effect of the higher price. So the change in their welfare is equal to $+2.9\%$ prior to the budget adjustment and $+5.0\%$ afterwards. Finally, high skill workers employed in services gain most from immigration. Not only their productivity increases, but also the price for their services is higher. This is associated with a change in welfare equal to $+4.7\%$ prior to the budget adjustment and $+6.3\%$ afterwards. Note that adverse immigration effects contribute to larger income inequality of incumbent workers.

We also perform a number of alternative calibrations and robustness checks. In particular, we compare our benchmark model with a competitive labour market framework. In both models immigration leads to higher demand for services which is not fully covered by the additional production of services, so the price of services is increasing. However, in the benchmark model with frictions higher price leads to more intensive job creation and accelerated reallocation of incumbent workers from unemployment into employment which is not possible in a competitive setting with full employment. Higher labour demand benefits workers in service occupations and mitigates the price increase in this sector, so the average increase in welfare is positive in the benchmark model with frictions but it is close to zero in a competitive setting.

Using a search and matching framework to address the impact of immigration is a relatively recent tendency in the literature. For example, Chassamboulli and Palivos (2014) have incorporated a nested CES production function with capital, skilled and unskilled labour into the frictional labour market and calibrated this model to the U.S. economy, which experienced a high-skill biased immigration in the period 2000-2009. They conclude that the overall effect of immigration in the U.S. in the considered period should be estimated as positive. Second closely related study is by Battisti et al. (2014). These authors calibrated their search and matching model to 20 different OECD countries and arrived at a general conclusion that immigration in the period 2000–2011 has increased the welfare of native workers in almost all these countries. Our model has a number of similarities with Battisti et al. (2014) e.g. the wage gap between natives and immigrants, redistributive fiscal policy and perfect substitution between these groups in the CES production function. However, there are also notable deviations, for example, in our model we consider two production sectors – manufacturing and services – with an endogenous price setting in services and vertical mismatch of native and immigrant workers. We find that the model with two production sectors is better in capturing the asymmetric effects of immigration on high and low skill workers, who are not equally distributed between these sectors. In particular, our model takes into account that labour market outcomes of low skill workers, who are overrepresented in manufacturing, are less sensitive to changes in the domestic output demand since manufactured goods are largely traded on the international market.

Another study by Ortega (2000) also deals with the issue of immigration in a frictional labour market. He considers a two–country model and shows that both equilibria with and without immigration between the two countries are possible, but the equilibrium with immigration Pareto dominates the other one. Finally, there are two other studies combining immigration and search frictions by Moreno-Galbis and Tritah (2016) and Nanos and Schluter (2014). In the former paper immigrant workers earn lower wages which leads to higher profits of firms. So they show theoretically and empirically that an inflow of immigrant workers intensifies job creation due to the higher expected profits of firms, which benefits natives and incumbent immigrants. This effect is also present in our study, however, in our model this positive effect is reduced due to the fact that not all matches between firms and immigrant workers lead to employment. The study by Nanos and Schluter (2014) constructs a theoretical search and matching model and calibrates it to the German data. One important advantage of Nanos and Schluter (2014) over our work is that they explicitly allow for on-the-job search of all workers in their model whereas in our model only mismatched high skill workers continue searching on-the-job. However, their model builds on the assumption that labour markets of immigrant workers are completely separated from those of natives, which is different in our model and allows us to quantify the general equilibrium effects of migration on native workers.

Next we turn to the characterization of the large literature on the effect of immigration in a competitive labour market framework without frictions. Two early studies by Borjas

(1999) and Ben?Gad (2004) consider a setting with homogeneous workers and show that the response of wages strongly depends on the mobility of capital stock. Schmidt, Stilz and Zimmermann (1994) and Ben?Gad (2008) extend this framework to the case of heterogeneous skill groups. Even though both skilled and unskilled wages are generally expected to fall with a skill-balanced immigration, the elasticity of labour demand and the skill direction of immigration are found to be crucial in this setting. Empirical evidence suggests that the demand for skilled labour is less elastic than the demand for unskilled labour. Hence according to these studies the immigration surplus is maximized when the inflow of immigrants is exclusively skilled. To the best of our knowledge Schmidt et al. (1994) is the only immigration study emphasizing the importance of incorporating labour unions and wage bargaining into the model, so they consider a right-to-manage model with a monopoly union, however, it is not calibrated to any specific economy.

Altonji and Card (1991) identify one of the positive general equilibrium effects of immigration. Specifically, in their model immigrants are likely to increase the overall demand for goods and services in the receiving country. This demand effect will tend to increase the overall demand for native labour, thus raising native wages and employment. Among more recent studies this idea is emphasized by Moretti (2010a,b), who writes that "Every time a local economy generates a new job..., additional jobs might also be created, mainly through increased demand for local goods and services" (multiplier effect). Even though Moretti (2010a,b) doesn't consider immigration he finds that for each additional job in manufacturing, 1.6 jobs are created in the non–tradable sector. Moreover, one additional skilled job in the tradable sector generates 2.5 job in local goods and services. It is a similar multiplier effect in response to immigration that we quantify in our study for Germany.

Recent studies investigating the effect of immigration started with the seminal approach by Borjas (2003) who observed that the rise in the U.S. immigration was not uniformly distributed across education/experience cells. This novel approach was further extended in the research of Manacorda, Manning and Wadsworth (2012) for the United Kingdom and D'Amuri, Ottaviano, Peri (2010) for Germany. These studies allow for the imperfect substitution of native and immigrant workers and show that the additional inflow of foreign workers to UK and Germany has a large negative effect on wages of the existing immigrants in the country leaving native wages virtually unaffected. This conclusion is supported by Felbermayr, Geis and Kohler (2010) who include the possibility of unemployment into the model and show that a new immigration inflow of workers from the east-ward enlargement of the European Union had a strong positive effect on the unemployment of incumbent foreign workers in Germany. On the contrary, the effect on native employment is very modest.

Dustmann and Preston (2012) have criticized the education-experience cell approach by observing that immigrant workers downgrade at arrival, which implies accepting jobs with a lower education/experience requirement than comparable native workers. Hence immigrants may compete with native workers at parts of the skill distribution which is different to where they should be assigned based on their observable characteristics. In response to this critique Dustmann, Frattini and Preston (2013) develop a new estimation strategy and study a continuous effect of immigration on workers situated at different quantiles of the earnings distribution. Their findings suggest that immigration reduced wages of natives below the

20th percentile of the wage distribution in the UK, but slightly increased wages in the upper part of the distribution.

Overall, all of these studies are focused on the effect of immigration on wages rather than (un)employment. Only D'Amuri et al. (2010) and Felbermayr et al. (2010) follow a reduced form approach and assume a negative relation between employment and wages, however, this assumption is not micro-founded and there is no economic mechanism in their model leading to this relationship. This is the primary difference between these studies and our approach.

The outline of the paper is as follows. Section 2.2 presents notation and the economic environment. Section 2.3 describes the model, while section 2.4 presents the calibration of the model to the German labour market. Section 2.5 contains our main results for the benchmark model. Section 2.6 includes extensions, robustness checks and some alternative calibrations. Finally, section 2.7 concludes the paper.

2.2 Economic environment

There are four demographic groups of workers: low skill immigrants g_I^L, low skill natives (g_N^L), high skill immigrants g_I^H and high skill natives g_N^H. The workers have homothetic preferences with a CES utility function and discount future utility flows at rate r. Labour supply is inelastic so the total labour force is fixed and normalized to 1:

$$g_I^L + g_N^L + g_I^H + g_N^H = 1 \tag{2.1}$$

We use the subscript n to denote the origin of the worker $\{I, N\}$ and the superscript i to indicate the skill level of the worker $\{L, H\}$. Every worker belongs to one of the two production sectors: (1) manufacturing or (2) services. Subscript j corresponds to the production sector $\{1, 2\}$, so that g_{jn}^i is the number of workers with origin n, skill level i belonging to the production sector j. With this notation we have: $g_n^i = g_{1n}^i + g_{2n}^i$. We assume that skills are specific to a given sector and not transferable, thus it is not possible for workers to change the sector. Low skill workers can be employed or unemployed, so that: $g_{jn}^L = e_{jn}^L + u_{jn}^L$, where e_{jn}^L is the number of employed low skill workers, u_{jn}^L – the number of unemployed low skill workers in a given origin-sector group. Unemployment is involuntary in our model and is generated by search frictions. High skill workers can be unemployed u_{jn}^H, employed in a job with low skill requirement (skill mismatch) m_{jn}^H and employed in a job with a high skill requirement e_{jn}^H, so that: $g_{jN}^H = u_{jn}^H + m_{jn}^H + e_{jn}^H$. This equation shows that high skill workers can be vertically mismatched in the sense of being overqualified for the job. To keep the model tractable we refrain from considering horizontal mismatch within the same skill group.

There are four labour markets in the economy depending on the production sector and the skill content of the job. Let v_j^i denote the number of vacancies in sector j with a skill requirement i. Further, let s_j^i denote the number of searching workers applying for vacancies v_j^i. Both native and immigrant workers apply to the same vacancies in a given labour market. The unemployed workers are matched with vacancies through a matching function given by $m(s^i_j, v^i_j)$. This matching function is homogeneous of degree 1, concave and increasing in both its arguments. Later we shall discuss the specific form we use for our empirical analysis. The group of searching workers in the low skill submarket s^L_j consists of low skill native and immigrant workers as well as high skill native and immigrant workers in sector j, that is $s^L_j = u^L_{jN} + u^L_{jI} + u^H_{jN} + u^H_{jI}$. This shows that high skill workers apply to low and high skill jobs simultaneously in order to maximize their employment chances. At the same time we assume that mismatched high skill workers $(m^H_{jN} + m^H_{jI})$ continue searching for better jobs in a high skill submarket. Taking into account on-the-job search of mismatched high skill workers, the group of searching workers in the high skill submarket s^H_j becomes: $s^H_j = u^H_{jN} + u^H_{jI} + m^H_{jN} + m^H_{jI}$. The rate at which a worker is matched with a vacant position in a specific labour market is $m(s^i_j, v^i_j)/s^i_j = \lambda(\theta^i_j)$, where $\theta^i_j = v^i_j/s^i_j$ reflects the tightness of the labour market in sector j with a skill requirement i:

$$\theta^L_j = \frac{v^L_j}{s^L_j} = \frac{v^L_j}{u^L_{jN} + u^L_{jI} + u^H_{jN} + u^H_{jI}} \quad \theta^H_j = \frac{v^H_j}{s^H_j} = \frac{v^L_j}{u^H_{jN} + u^H_{jI} + m^H_{jN} + m^H_{jI}}$$

Even though the probability of matching with vacancies $\lambda(\theta^i_j)$ is identical for all workers searching in a given labour market, their hiring chances are not. This difference is captured by additional parameters h^k_{jn}, $k = L, M, H$, where M is used for mismatched high skill workers. We normalize the hiring chances of native workers with a proper skill requirement to 1, that is: $h^L_{jN} = 1$ and $h^H_{jN} = 1$, $j = 1, 2$. Parameters h^L_{jI} and h^H_{jI} reflect the hiring chances of immigrant workers relative to the hiring chances of native workers in the corresponding submarket. Intuitively, these two parameters capture a lower language proficiency of immigrant workers and/or hiring discrimination by firms[3]. We expect that $h^L_{jI} < h^L_{jN} = 1$ and $h^H_{jI} < h^H_{jN}$ hence the job-finding rates for immigrant workers with a proper skill requirement becomes $h^L_{jI}\lambda(\theta^L_j) \leq \lambda(\theta^L_j)$ and $h^H_{jI}\lambda(\theta^H_j) \leq \lambda(\theta^H_j)$. The other two parameters h^M_{jN} and h^M_{jI} reflect the hiring chances of mismatched high skill workers applying to low skill jobs. These parameters can be larger than $h^L_{jN} = 1$ if firms expect additional gains by hiring high skill workers to low skill positions. Next the rate at which a firm is matched with some worker is $m(s^i_j, v^i_j)/v^i_j = q(\theta^i_j)$. Thus $q(\theta^i_j)$ is a contact rate for open vacancies. Since the matching function is increasing in both arguments we have: $\lambda'(\theta^i_j) > 0$ while $q'(\theta^i_j) < 0$. Every job can be destroyed at rate δ due to some adverse exogenous shock. We assume that this rate is identical for all worker groups.

Unemployed individuals receive benefits b^i_{jn}, $i = L, H$ which are financed from the public budget. If there is positive budget surplus remaining after the unemployment benefits are paid out it is distributed as a lump-sum transfer $T \geq 0$ to all agents. Let t denote the income tax, so that workers receive the flow income $w^k_{jn}(1 - t)$ from their employers and T from the public budget. Unemployment benefits are not taxed. Given the total disposable income workers maximize their utility $\Omega(c_1, c_2)$ by choosing the optimal consumption bundle (c_1, c_2) subject to the budget constraint. Finally, we assume that manufactured goods are

[3]See Constant, Shachmurove and Zimmermann (2005), Constant and Zimmermann (2006), Kaas and Manger (2012), Constant and Rinne (2013) for hiring discrimination between natives and immigrants in Germany.

traded on international markets and their price p_1 is fixed. On the contrary, service sector is non-tradable, and its price is endogenous in the model. In the equilibrium p_2 is determined at the point where the aggregate demand for services is equal to the aggregate supply of services.

2.3 The Model

In terms of production we follow the approach of Acemoglu (2001) and assume that submarkets with different skill requirements produce different intermediate goods which are used in the production of the final good in each of the two production sectors. The total input of low skill intermediate goods in sector $j = 1, 2$ is equal to $n_j^L \equiv e_{jI}^L + \psi_{jN}^L e_{jN}^L + \psi_{jI}^M m_{jI}^H + \psi_{jN}^M m_{jN}^H$ as it is produced by employed low skill workers and mismatched high skill workers who can be native or immigrant. Even though we assume perfect substitution between native and immigrant workers (infinite elasticity of substitution), we do allow for differences in the effective productivity of these groups reflected in parameters ψ_{jn}^k. This assumption is motivated by the findings in empirical studies, reporting finite but large elasticities of substitution between native and immigrant workers in the range between 20 and 30[4]. The total input of high skill intermediate goods in sector j is equal to $n_j^H \equiv e_{jI}^H + \psi_{jN}^H e_{jN}^H$. The total output Y_j of the final good in sector $j = 1, 2$ is given by the CES production function:

$$Y_j = \left(\chi_j (n_j^L)^{\frac{\rho-1}{\rho}} + (1-\chi_j)(n_j^H)^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}$$

where ρ is the elasticity of substitution between high and low skill labour. In the limiting case when $\rho \to 1$, this production function converges to the Cobb-Douglas technology with the power parameter χ_j. Intermediate goods are sold in a competitive market, thus intermediate goods producers are paid the marginal productivity of their goods, that is $p_j y_{jn}^k$, $k = L, M, H$ where p_j is the price per unit of the final good and $y_{jn}^L = \partial Y_j / \partial e_{jn}^L$, $y_{jn}^M = \partial Y_j / \partial m_{jn}^H$ and $y_{jn}^H = \partial Y_j / \partial e_{jn}^H$ are the units of output.

Given the CES technology, the marginal productivities y_{jI}^L and y_{jI}^H can be found as:

$$\begin{aligned} y_{jI}^L &= \frac{\partial Y_j}{\partial e_{jI}^L} = \left(\chi_j (n_j^L)^{\frac{\rho-1}{\rho}} + (1-\chi_j)(n_j^H)^{\frac{\rho-1}{\rho}} \right)^{\frac{1}{\rho-1}} \chi_j (n_j^L)^{\frac{-1}{\rho}} \\ y_{jI}^H &= \frac{\partial Y_j}{\partial e_{jI}^H} = \left(\chi_j (n_j^L)^{\frac{\rho-1}{\rho}} + (1-\chi_j)(n_j^H)^{\frac{\rho-1}{\rho}} \right)^{\frac{1}{\rho-1}} (1-\chi_j)(n_j^H)^{\frac{-1}{\rho}} \end{aligned}$$

All the remaining marginal productivities can be found as functions of y_{jI}^L or y_{jI}^H: The marginal products of different worker groups are then given by:

$$y_{jN}^L = \frac{\partial Y_j}{\partial e_{jN}^L} = \psi_{jN}^L y_{jI}^L \qquad y_{jN}^H = \frac{\partial Y_j}{\partial e_{jN}^H} = \psi_{jN}^H y_{jI}^H \tag{2.2}$$

$$y_{jN}^M = \frac{\partial Y_j}{\partial m_{jN}^H} = \psi_{jN}^M y_{jI}^L \qquad y_{jI}^M = \frac{\partial Y_j}{\partial m_{jI}^H} = \psi_{jI}^M y_{jI}^L \tag{2.3}$$

[4]See the debate in Ottaviano and Peri (2012)

Intermediate goods producers can open vacancies in each of the two sectors with the corresponding up-front cost K_j per vacancy. Intuitively, this corresponds to the cost of capital necessary for the production. Having paid the entry cost in a given sector, firms are free to open a position with one of the two skill requirements. In the equilibrium, the number of vacancies v_j^i is determined at the point where the present value of expected profits is equal to the entry cost, that is $V_j^L = K_j$ and $V_j^H = K_j$ (free-entry conditions). These free-entry conditions imply that in the equilibrium firms are indifferent between opening a high skill position with a present value of expected profits V_j^H and a low skill position with a present value of expected profits V_j^L, so that: $V_j^L = V_j^H$ (indifference condition). Let γ_j^i denote the flow cost of recruitment in a submarket i, j. Note that recruitment costs and expected profits depend on the skill content of the job. Afterwards, when the position is filled, there are no other costs than gross wages w_{jn}^k.

2.3.1 Demand Side of the Economy

The pool of consumers is given by employees and unemployed individuals. There is no possibility of saving income or transferring it over time. Let M_{jn}^k denote the net disposable income of a given consumer which can be $w_{jn}^k(1-t)+T$, $k = L, M, H$ for employed workers or $b_{jn}^i + T$, $i = L, H$ for unemployed individuals. The CES utility function $\Omega(c_1, c_2)$ is given by:

$$\Omega(c_1, c_2) = [a_1 c_1^{\frac{\sigma-1}{\sigma}} + a_2 c_2^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}} \tag{2.4}$$

where c_1 is consumption of good 1 (manufactured good) and c_2 is consumption of good 2 (services). Moreover, $a_1 + a_2 = 1$ and $\sigma > 0$ is the elasticity of substitution between the two goods. If $\sigma \to \infty$ the two goods are perfect substitutes, in contrast, when $\sigma \to 0$, the two goods are perfect complements. Note that there are no other differences among consumers apart from their income. The utility maximization problem determines the quantity of goods demanded and gives the following solution:

$$\max_{c_1, c_2} \Omega(c_1, c_2) \quad \text{s.t.} \quad p_1 c_1 + p_2 c_2 = M_{jn}^k \quad \Rightarrow \quad c_j(p_1, p_2, M_{jn}^k) = \frac{M_{jn}^k \left(\frac{p_j}{a_j}\right)^{-\sigma}}{p_1 \left(\frac{p_1}{a_1}\right)^{-\sigma} + p_2 \left(\frac{p_2}{a_2}\right)^{-\sigma}}$$

It is straightforward to see that consumption $c_j(p_1, p_2, M_{jn}^k)$ is increasing in the income M_{jn}^k but decreasing in its price p_j. The aggregate income in the economy is equal to $p_1 Y_1 + p_2 Y_2$ and it can be used for consumption of manufactured goods or services. Thus we get the following equilibrium equation for services:

$$\frac{(p_1 Y_1 + p_2 Y_2)\left(\frac{p_2}{a_2}\right)^{-\sigma}}{p_1 \left(\frac{p_1}{a_1}\right)^{-\sigma} + p_2 \left(\frac{p_2}{a_2}\right)^{-\sigma}} = Y_2 \qquad \Rightarrow \qquad p_2 = p_1 \left(\frac{a_2}{a_1}\right) \left(\frac{Y_2}{Y_1}\right)^{-\frac{1}{\sigma}}$$

where the left-hand side is the aggregate demand for services and the right-hand side is the output. Since the price p_1 is fixed, we can see that a higher output of good 2 (services) has a negative effect on the price of services p_2. However, an increase in Y_1 has a positive effect on the price p_2. This is because higher production of manufactured goods Y_1 implies higher income of workers in this sector and higher demand not only for manufactured goods but also for services. And a higher demand for services is associated with a higher price p_2.

In addition, note that the indirect utility of consumers Ω^k_{jn} is given by:

$$\Omega^k_{jn} \equiv \Omega(c_1(p_1, p_2, M^k_{jn}), c_2(p_1, p_2, M^k_{jn})) = \frac{M^k_{jn}}{P} \quad \text{where} \quad P = \Big[p_1\big(\frac{p_1}{a_1}\big)^{-\sigma} + p_2\big(\frac{p_2}{a_2}\big)^{-\sigma}\Big]^{\frac{1}{1-\sigma}}$$

Here P is the aggregate price index and it is increasing in each of the prices p_1 and p_2. Thus higher prices are associated with lower consumers' utility $\Omega(p_1, p_2, M^k_{jn})$.

2.3.2 Present value equations

Let V^i_j be the present value of an open vacancy for firms operating in submarket i, j. First, consider the low skill submarket $i = L$. Let J^L_{jn} be the present value of profits associated with hiring a low skill worker in this submarket and J^M_{jn} be the present value of profits associated with hiring a high skill worker for performing a low skill job (mismatch case). The present value of a given low skill vacancy is then given by:

$$\begin{aligned} rV^L_j &= -\gamma^L_j + q(\theta^L_j)\Big[\frac{u^L_{jN}}{s^L_j}(J^L_{jN} - V^L_j) + \frac{u^L_{jI}}{s^L_j}h^L_{jI}(J^L_{jI} - V^L_j) \\ &+ \frac{u^H_{jN}}{s^L_j}h^M_{jN}(J^M_{jN} - V^L_j) + \frac{u^H_{jI}}{s^L_j}h^M_{jI}(J^M_{jI} - V^L_j)\Big] \end{aligned} \tag{2.5}$$

Parameter γ^L_j is a flow recruitment cost in the low skill submarket. At rate $q(\theta^L_j)$ the firm is matched with some applicant, who can be a low skill native worker (with probability u^L_{jN}/s^L_j), a low skill immigrant worker (with probability u^L_{jI}/s^L_j), a high skill native worker (with probability u^H_{jN}/s^L_j) or a high skill immigrant worker (with probability u^H_{jI}/s^L_j). Note that these four probabilities add up to 1. Parameters h^L_{jn} and h^M_{jn} are the relative probabilities of hiring the applicant conditional on a match. They are measured relative to the hiring chances of native low skill workers ($h^L_{jN} = 1$) and can be larger or smaller than 1.

The present values of filled jobs are given by the following equations

$$rJ^L_{jn} = p_j y^L_{jn} - w^L_{jn} - \delta(J^L_{jn} - V^L_j) \qquad rJ^M_{jn} = p_j y^M_{jn} - w^M_{jn} - (h^H_{jn}\lambda(\theta^H_j) + \delta)(J^M_{jn} - V^L_j) \tag{2.6}$$

where $p_j y^L_{jn}$ and $p_j y^M_{jn}$ are the values of output produced by the worker and w^L_{jn} and w^M_{jn} are the nominal gross wages reflecting the cost of labour. In addition, at rate δ the job can be destroyed. Note that firms expect a positive quitting possibility of mismatched high skill workers. This happens because high skill workers employed in low skill jobs continue searching on-the-job and quit if they find better jobs corresponding to their formal qualification. Job quits occur at rate $\lambda(\theta^H_j)$ for native high skill workers and at rate $h^H_{jI}\lambda(\theta^H_j)$ for immigrant high skill workers. The net present values of profits $J^L_{jn} - V^L_j$ and $J^M_{jn} - V^L_j$ are then expressed as:

$$J^L_{jn} - V^L_j = \frac{p_j y^L_{jn} - w^L_{jn} - rV^L_j}{r+\delta} \qquad J^M_{jn} - V^L_j = \frac{p_j y^M_{jn} - w^M_{jn} - rV^L_j}{r+\delta+h^H_{jn}\lambda(\theta^H_j)} \tag{2.7}$$

Recall that firms have to pay an up-front cost K_j of capital for entering sector j. Due to the free-entry, in the equilibrium we have that $K_j = V^L_j$, which is equivalent to:

$$\begin{aligned} rK_j &= -\gamma^L_j + q(\theta^i_j)\Bigg[\frac{u^L_{jN}}{s^L_j}\Big(\frac{p_j y^L_{jN} - w^L_{jN} - rK_j}{r+\delta}\Big) + h^L_{jI}\frac{u^L_{jI}}{s^L_j}\Big(\frac{p_j y^L_{jI} - w^L_{jI} - rK_j}{r+\delta}\Big) \\ &+ h^M_{jN}\frac{u^H_{jN}}{s^L_j}\Big(\frac{p_j y^M_{jN} - w^M_{jN} - rK_j}{r+\delta+h^H_{jN}\lambda(\theta^H_j)}\Big) + h^M_{jI}\frac{u^H_{jI}}{s^L_j}\Big(\frac{p_j y^M_{jI} - w^M_{jI} - rK_j}{r+\delta+h^H_{jI}\lambda(\theta^H_j)}\Big)\Bigg] \end{aligned} \tag{2.8}$$

Second, consider the labour market for high skill jobs in sector j with a present value of expected profits V^H_j given by:

$$rV^H_j = -\gamma^H_j + q(\theta^H_j)\Big[\frac{u^H_{jN} + m^H_{jN}}{s^H_j}(J^H_{jN} - V^H_j) + h^H_{jI}\frac{u^H_{jI} + m^H_{jI}}{s^H_j}(J^H_{jI} - V^H_j)\Big] \tag{2.9}$$

Here γ^H_j is the flow cost of an open high skill job. Firms are matched with applicants at rate $q(\theta^H_j)$. The applicant can be an unemployed or mismatched native worker (with probability $(u^H_{jN} + m^H_{jN})/s^H_j$) generating a present value of profits J^H_{jN} for the firm. Alternatively, it can be an unemployed or mismatched immigrant worker (with probability $(u^H_{jI} + m^H_{jI})/s^H_j$) generating a present value of profits for the firm J^H_{jI}. Note that immigrant workers may face a lower acceptance probability h^H_{jI} compared to native workers $h^H_{jN} = 1$. Further, we assume that mismatched workers can not use their stronger labour market status compared to unemployed workers and receive the same wage w^H_{jn}. Similar assumption was used by Gautier (2002)[5].

The present values of filled jobs in the high skill submarket are given by:

$$rJ^H_{jn} = p_j y^H_{jn} - w^H_{jn} - \delta(J^H_{jn} - V^H_j) \tag{2.10}$$

The free-entry condition in the high skill submarket $V^H_j = K_j$ then becomes:

$$rK_j = -\gamma^H_j + q(\theta^H_j)\Big[\frac{u^H_{jN} + m^H_{jN}}{s^H_j}\Big(\frac{p_j y^H_{jN} - w^H_{jN} - rK_j}{r+\delta}\Big) + h^H_{jI}\frac{u^H_{jI} + m^H_{jI}}{s^H_j}\Big(\frac{p_j y^H_{jI} - w^H_{jI} - rK_j}{r+\delta}\Big)\Big] \tag{2.11}$$

Next we consider the present value equations for workers. There are four types of unemployed individuals in every sector j depending on their ethnic origin n and the skill level i. Let their

[5] As an alternative specification one could introduce two separate wages, one for applicants coming from unemployment and another wage for applicants coming from mismatch. The second wage would be higher, so firms will have a strong incentive to renegotiate the wage as soon as the worker quits the low skill job (see Gautier (2002)). So the situation with two separate wages is not renegotiation proof and we continue by assuming a single wage w^H_{jn} for both types of applicants.

present values of income be denoted by U^i_{jn}. These individuals receive the unemployment benefit b^i_{jn} and a lump-sum transfer from the public budget T. Their indirect utility is then given by $\Omega(p_1, p_2, b^i_{jn}) = (b^i_{jn} + T)/P$ since unemployment benefits are not taxed and their present values of unemployment can be written as:

$$rU^L_{jn} = \frac{b^L_{jn} + T}{P} + h^L_{jn}\lambda(\theta^L_j)(W^L_{jn} - U^L_{jn}) \tag{2.12}$$

$$rU^H_{jn} = \frac{b^H_{jn} + T}{P} + h^M_{jn}\lambda(\theta^L_j)(W^M_{jn} - U^H_{jn}) + h^H_{jn}\lambda(\theta^H_j)(W^H_{jn} - U^H_{jn}) \tag{2.13}$$

Note that unemployed low skill workers are not eligible for high skill jobs and have worse employment opportunities than high skill workers who can apply to jobs with high and low skill requirement. So the total job-finding rate for high skill workers becomes $h^M_{jn}\lambda(\theta^L_j) + h^H_{jn}\lambda(\theta^H_j)$. However, their wages depend on the quality of the match. Variables W^k_{jn}, $k = L, M, H$ are the present values from employment in a respective state k. Note that these equations are based on the assumption that unemployed workers search for jobs in their primary production sector and do not change the sector. Even though this assumption is restrictive, it is supported by our empirical findings of relatively low cross-sectional labour mobility in Germany presented in a working paper version of this study[6]. Moreover, other studies such as Nanos and Schluter (2014) also report evidence on strong sectoral immobility in Germany.

The present values of income in employment are given by the following equations:

$$rW^L_{jn} = \frac{w^L_{jn}(1-t) + T}{P} - \delta(W^L_{jn} - U^L_{jn}) \qquad rW^H_{jn} = \frac{w^H_{jn}(1-t) + T}{P} - \delta(W^H_{jn} - U^H_{jn}) \tag{2.14}$$

$$rW^M_{jn} = \frac{w^M_{jn}(1-t) + T}{P} + h^H_{jn}\lambda(\theta^H_j)(W^H_{jn} - W^M_{jn}) - \delta(W^M_{jn} - U^H_{jn}) \tag{2.15}$$

Note here that mismatched high skill workers anticipate to quit their low skill jobs if they find employment in the high skill submarket, which happens at rate $h^H_{jn}\lambda(\theta^H_j)$. Moreover, there is a rent $(W^H_{jn} - W^M_{jn})$ associated with this job change. Considering transitions from unemployment into employment we find the following rents for different worker groups:

$$W^i_{jn} - U^i_{jn} = \frac{[w^i_{jn}(1-t) + T]/P - rU^i_{jn}}{r + \delta} \qquad i = L, H$$

$$W^M_{jn} - U^H_{jn} = \frac{[w^M_{jn}(1-t) + T]/P - rU^H_{jn} + h^H_{jn}\lambda(\theta^H_j)(W^H_{jn} - U^H_{jn})}{r + \delta + h^H_{jn}\lambda(\theta^H_j)}$$

These equations will be used later in the paper as a basis for the Nash-bargaining wage-setting mechanism. Finally, we can write down the government budget constraint:

$$\sum_{n=N,I,j=1,2} t(w^L_{jn}e^L_{jn} + w^M_{jn}m^H_{jn} + w^H_{jn}e^H_{jn}) - (b^L_{jn}u^L_{jn} + b^H_{jn}u^H_{jn}) = T \tag{2.16}$$

[6] Iftikhar Z., A. Zaharieva, "General Equilibrium Effects of Immigration in Germany: Search and Matching Approach", IMW working paper Nr. 568, Center for Mathematical Economics, Bielefeld, Germany.

where the first term on the left-hand side is the total revenue from taxes on labour income. The second term corresponds to the total expenditures on unemployment benefits, while T is the remaining budget surplus which is distributed as a lump-sum payment to all economic agents. Recall that the total population size is normalized to 1, so T is a payment per person.

2.3.3 Steady state values of unemployment and mismatch employment

The total stock of low skill workers in sector j with ethnic origin n is given by g^L_{jn} and consists of employed and unemployed workers: $g^L_{jn} = e^L_{jn} + u^L_{jn}$. Combining this equation with the differential equation for u^L_{jn} in the steady state we get:

$$0 = \dot{u}^L_{jn} = \delta(g^L_{jn} - u^L_{jn}) - h^L_{jn}\lambda(\theta^L_j)u^L_{jn} \quad \Rightarrow \quad u^L_{jn} = \frac{\delta g^L_{jn}}{\delta + h^L_{jn}\lambda(\theta^L_j)} \tag{2.17}$$

This equation implies that the change in the stock of workers $\dot{u}^L_{jn}$ is given by the inflow of employed workers losing jobs $(\delta(g^L_{jn} - u^L_{jn}))$ minus the outflow of unemployed workers finding jobs $(h^L_{jn}\lambda(\theta^L_j)u^L_{jn})$. Next consider the differential equations for unemployed high skill workers $\dot{u}^H_{jn}$ in the steady state:

$$0 = \dot{u}^H_{jn} = \delta m^H_{jn} + \delta(g^H_{jn} - m^H_{jn} - u^H_{jn}) - (h^M_{jn}\lambda(\theta^L_j) + h^H_{jn}\lambda(\theta^H_j))u^H_{jn}$$

The first two terms on the right-hand side correspond to the inflow of high skill workers into unemployment because of the job destruction shock δ, note that $g^H_{jn} - m^H_{jn} - u^H_{jn} = e^H_{jn}$. The latter two terms correspond to the outflow of high skill workers finding jobs either in the low skill submarket (mismatch) or in the high skill submarket. Finally, consider the differential equation for mismatched high skill workers $\dot{m}^H_{jn}$:

$$0 = \dot{m}^H_{jn} = h^M_{jn}\lambda(\theta^L_j)u^H_{jn} - h^H_{jn}\lambda(\theta^H_j)m^H_{jn} - \delta m^H_{jn}$$

Here the first term on the right-hand side corresponds to unemployed high skill workers accepting mismatch employment in the low skill submarket, whereas the last two terms are the outflows of mismatched workers due to quits and job destruction shocks. Combining the two steady-state equations $0 = \dot{u}^H_{jn}$ and $0 = \dot{m}^H_{jn}$ we get the following distribution of high skill workers:

$$u^H_{jn} = \frac{\delta g^H_{jn}}{\delta + h^M_{jn}\lambda(\theta^L_j) + h^H_{jn}\lambda(\theta^H_j)} \qquad m^H_{jn} = \frac{h^M_{jn}\lambda(\theta^L_j)\delta g^H_{jn}}{(\delta + h^M_{jn}\lambda(\theta^L_j) + h^H_{jn}\lambda(\theta^H_j))(\delta + h^H_{jn}\lambda(\theta^H_j))} \tag{2.18}$$

These equations show, for example, that higher job-finding rates $h^i_{jn}\lambda(\theta^i_j)$, $i = L, H$ and $h^M_{jn}\lambda(\theta^L_j)$ are generally associated with lower unemployment rates u^L_{jn}/g^L_{jn} and u^H_{jn}/g^H_{jn}.

2.3.4 Wage determination through Nash Bargaining

Once matched, workers and firms bargain over the wage, where the net gain of high and low skill workers in good matches is given by $W^i_{jn} - U^i_{jn}$, $i = L, H$ and the net gain of the firm is $J^i_{jn} - V^i_j$, $i = L, H$. For high skill workers matched with low skill jobs (mismatch) the worker's gain is $W^M_{jn} - U^H_{jn}$, while the firm is getting the net profit $J^M_{jn} - V^L_j$. Let the bargaining power of workers in submarket i, j be given by β^i_j. Consider first good matches, so the bargaining problem is given by ($i = L, H$):

$$\Big(\frac{[w^i_{jn}(1-t)+T]/P - rU^i_{jn}}{r+\delta}\Big)^{\beta^i_j} \cdot \Big(\frac{p_j y^i_{jn} - w^i_{jn} - rV^i_j}{r+\delta}\Big)^{(1-\beta^i_j)} \longrightarrow \max w^i_{jn}$$

Both workers and firms take their outside options U^i_{jn} and V^i_j as given in the process of Nash bargaining. Even though the two first order conditions for w^L_{jn} and w^H_{jn} are similar in their general form, they differ after we insert the present values of unemployment rU^L_{jn} and rU^H_{jn}, so we get the following equilibrium equations for wages $i = L, H$[7]:

$$w^i_{jn} = \frac{\beta^i_j(p_j y^i_{jn} - rV^i_j)(r+\delta+h^i_{jn}\lambda(\theta^i_j)) + (1-\beta^i_j)(r+\delta)\tilde{b}^i_{jn}/(1-t)}{r+\delta+h^i_{jn}\lambda(\theta^i_j)\beta^H_j} \tag{2.19}$$

$$\text{where} \quad \tilde{b}^L_{jn} = b^L_{jn} \quad \text{and} \quad \tilde{b}^H_{jn} = \frac{[b^H_{jn}(r+\delta+h^H_{jn}\lambda(\theta^H_j)) + h^M_{jn}\lambda(\theta^L_j)w^M_{jn}(1-t)]}{r+\delta+h^H_{jn}\lambda(\theta^H_j)+h^M_{jn}\lambda(\theta^L_j)}$$

These equations show that the wage w^i_{jn} is a weighted average between the net productivity $p_j y^i_{jn} - rV^i_j$ and an auxiliary variable $\tilde{b}^i_{jn}$. This variable is an average income of workers when they are not employed in a good match. For low skill workers the only alternative to employment is the state of unemployment, so that $\tilde{b}^L_{jn} = b^L_{jn}$. So the wage w^L_{jn} is a weighted average between the net productivity and the unemployment benefit b^L_{jn} We can also see that the weight on the unemployment benefit is decreasing with the higher market tightness θ^L_j, while the weight on the net marginal productivity is increasing in θ^L_j. This means that better chances of finding a job reflected in the market tightness θ^L_j are associated with a better bargaining position of workers and lead to a higher wage w^L_{jn}.

High skill workers have a better set of alternatives as they can be mismatched in a low skill job with income w^M_{jn} or unemployed and receiving the unemployment benefit b^H_{jn}. So the auxiliary variable $\tilde{b}^H_{jn}$ is a weighted average between the unemployment benefit b^H_{jn} and the mismatch wage w^M_{jn}. Thus we can see that the wage w^H_{jn} is a weighted average between the net productivity, the unemployment benefit and the mismatch wage where the weights correspond to the average time that workers spend in each of the three states. In the hypothetical case when $h^M_{jn} = 0$, that is high skill workers are never accepted in low skill jobs, we get that $\tilde{b}^H_{jn} = b^H_{jn}$. In this situation the wage w^H_{jn} is reduced to being a weighted average between the net productivity of high skill workers and their unemployment benefit.

Recall, that in the equilibrium with free-entry we have that $K_j = V^i_j$, so that higher start-up costs increase the required present value of an open vacancy V^i_j. However, this is only possible if the present value of profits is higher, which can be achieved with a lower wage. This explains the negative effect of V^i_j on wages. So in the equilibrium workers bear a part of the higher start-up cost K_j. Finally, note that the lump-sum transfers T are not distortive as all individuals are eligible for receiving these transfers from the budget in every labour market state. So variable T doesn't enter the wage equations.

[7]See appendix A for the proof

Next consider mismatched high skill workers. Getting a low skill job is associated with a job rent $W_{jn}^M - U_{jn}^H$ as stated above, so the bargaining problem is given by:

$$\Big(\frac{[w_{jn}^M(1-t)+T]/P - rU_{jn}^H + h_{jn}^H\lambda(\theta_j^H)(W_{jn}^H - U_{jn}^H)}{r+\delta+h_{jn}^H\lambda(\theta_j^H)}\Big)^{\beta_j^i} \cdot \Big(\frac{p_j y_{jn}^M - w_{jn}^M - rV_j^L}{r+\delta+h_{jn}^H\lambda(\theta_j^H)}\Big)^{(1-\beta_j^i)} \longrightarrow \max w_{jn}^i$$

When bargaining both workers and firms take the quitting probability $h_{jn}^H\lambda(\theta_j^H)$ as given, thus it is not affected by the wage. In addition, one can see that the market tightness θ_j^H in the high skill submarket has a negative impact on the profits of firms as it becomes more likely that mismatched high skill workers quit their jobs. Deriving the first order condition, we get the following equilibrium equation for the mismatch wage w_{jn}^M:

$$w_{jn}^M = \frac{\beta_j^L(p_j y_{jn}^M - rV_j^L)[r+\delta+h_{jn}^H\lambda(\theta_j^H)+h_{jn}^M\lambda(\theta_j^L)] + (1-\beta_j^L)b_{jn}^H[r+\delta+h_{jn}^H\lambda(\theta_j^H)]/(1-t)}{r+\delta+h_{jn}^H\lambda(\theta_j^H)+h_{jn}^M\lambda(\theta_j^L)\beta_j^L} \tag{2.20}$$

This equation shows that the wage w_{jn}^M is again a weighted average between the net productivity $p_j y_{jn}^M - rV_j^L$ of mismatched workers and the unemployment benefit b_{jn}^H. We can also see that the mismatch wage w_{jn}^M does not directly depend on the high skill wage w_{jn}^H. The reason is that high skill workers don't give up their option of continuing to search for a better job. So the value of this option $h_{jn}^H\lambda(\theta_j^H)(W_{jn}^H - U_{jn}^H)$ is not lost upon accepting a low skill job and it cancels out once we insert the present value of unemployment rU_{jn}^H.

2.4 Calibration

To calibrate our model we use data from the German Socio-Economic Panel, wave 2011, which is a large survey of individuals. The German labour market was not strongly affected by the global financial crisis in 2007-2008, the aggregate unemployment rate went slightly up to 8.1% in 2009 and then down to 7.1% in the year 2011[8]. Möller (2010) and Funk (2012) emphasize the role of labour market reforms and institutions in mitigating the effect of the financial crisis such as working-time accounts and short-time work schemes which were effectively used by firms to cope with a temporary drop in demand in 2009. Due to these adjustment mechanisms the negative consequences of the financial crisis were overcome by the year 2011 and so we use cross-sectional data from this year to calibrate our model. In addition, 2011 was a year of the most recent population census in Germany, so the aggregate numbers of native and immigrant workers are particularly reliable in this year and suitable for calibrating a steady-state model. Our primary task is then to analyze the long-term implications of the post-crisis immigration wave that took place in 2012-2016.

Table 2.1 gives the basic profile of the sample we use for our analysis. We have a sample of 14282 individuals. These are the regularly employed full- and part-time workers or registered unemployed. Marginally employed workers, self-employed, retired people and other non-participants are excluded from our sample. The immigration rate is equal to 9.1%. We use

[8]Statistik der Bundesagentur für Arbeit, Arbeitslosigkeit im Zeitverlauf, March 2016

a broad definition of immigration which includes foreign citizens and naturalized citizens (who changed their foreign citizenship for the German one at some point in their life). Exact definitions of all variables are presented in the appendix. High skill workers are defined as those who completed more than 12 years of schooling, which includes individuals with university and college degrees. In our sample, 28% of immigrants and 41% of natives are high skilled, which shows that there is a larger proportion of low skilled among immigrant workers compared to natives.

Table 2.1: Sample Profile. German Socio-Economic Panel, wave 2011

Sector 1 Manufacturing $g_1 = 0.4569$			
Low skill $\frac{g_1^L}{g_1} = 0.7386$		High skill $\frac{g_1^H}{g_1} = 0.2614$	
Native $\frac{g_{1N}^L}{g_1^L} = 0.8683$	Immigrant $\frac{g_{1I}^L}{g_1^L} = 0.1317$	Native $\frac{g_{1N}^H}{g_1^H} = 0.9208$	Immigrant $\frac{g_{1I}^H}{g_1^H} = 0.0792$
Sector 2 Services $g_2 = 0.5431$			
Low skill $\frac{g_2^L}{g_2} = 0.4820$		High skill $\frac{g_2^H}{g_2} = 0.5180$	
Native $\frac{g_{2N}^L}{g_2^L} = 0.9183$	Immigrant $\frac{g_{2I}^L}{g_2^L} = 0.0817$	Native $\frac{g_{2N}^H}{g_2^H} = 0.9424$	Immigrant $\frac{g_{2I}^H}{g_2^H} = 0.0576$

Sector 1 includes such industries as agriculture, energy, mining, manufacturing, construction and trade, whereas Sector 2 includes transportation, banking, insurance and other services such as health care and education. As one can see from table 2.1, 46% of workers in our sample are assigned to Sector 1 versus 54% of workers are in sector 2. 74% of workers in sector 1 are low skilled, while only 48% are low skilled in sector 2, which reflects the fact that mining, manufacturing and construction are low skill intensive sectors, while service occupations are balanced in terms of skill requirements. We can also see that immigrant workers are overrepresented in low skill manufacturing and construction jobs with a rate of 13% and underrepresented in high skill service occupations with an average rate below 6%.

2.4.1 Transition rates

In this subsection we calibrate the transition rates and set a vector of parameters: $\{r, \delta, h_{jn}^k, \eta, \lambda_0\}$. First, we choose the annual discount rate equal to 4%, which means $r = 0.01$ on a quarterly basis. The average job duration for employed workers is equal to 12.25 years or 49 quarters[9]. Thus we set $\delta = 1/49 \approx 0.02$.

[9]The job duration of immigrant workers is below the average and is equal to 10.25 years or 41 quarters, which corresponds to the quarterly job destruction rate of 0.024. Even though the difference between this number and 0.02 for native workers is significantly different from 0, it doesn't fully explain observed differences in unemployment rates between native and immigrant workers indicating differences in the job-finding rates. Since we already allow for heterogeneous job-finding rates of the two ethnic groups we use

We use two binary probit regressions in order to predict the unemployment and mismatch rates for the corresponding worker groups. Our results are summarized in table A1 in the appendix. For our calibration we use predicted values of unemployment and mismatch rates rather than their sample averages. This has an advantage for smaller groups since regression predictions are based on the smoothness assumption, whereas sample averages are subject to stronger randomness and exhibit larger volatility in small samples. For the mismatch probit regression the sample is limited to high skill workers since the focus of our study is on overqualification and vertical mismatch of educated workers. The mismatch variable takes value 1 if the individual gives a "No" answer to the question: "Does your current job correspond to the acquired profession/training?" and the individual reports that the reason for mismatch is that college/university degree is not required for performing the job.

Column (1) in table A1 in appendix presents the coefficients from the mismatch probit regression. Column (2) presents the corresponding marginal effects of explanatory variables on the probability of mismatch[10]. We can see that native workers are facing about 9% lower probability of overqualification than immigrant workers. It is a well-known fact that high skill immigrant workers are often employed in low skill occupations, similar numbers are reported in a recent study by Salikutluk et al. (2016). Using GSOEP data, wave 2013, they report that 20% of native workers in Germany are overqualified, whereas the number is 30% for immigrant workers. So the difference is remarkably close to our estimate. Salikutluk et al. (2016) also show that 27% of former refugees are overqualified. This rate is only moderately smaller than the mismatch rate of labour migrants, which supports our approach of merging labour migrants and refugees into one group. Further, the mismatch rate is about 10% lower in sector 2 (Services). One possible explanation for this difference is that the number of service jobs is steadily increasing in the recent decade, so it is easier for workers to find a good match in services (see figure 2.1, left panel). In contrast, the number of jobs in manufacturing is decreasing making it more difficult to find a good match, especially for immigrant workers, forcing more of them into mismatch. As one can see from the figure, the turning point for this tendency was in 2008. According to the aggregate statistics in 2011 there were 51% of workers employed in services and 49% – in manufacturing. Thus our micro-level survey data with a corresponding distribution in manufacturing and services equal to $(54\%, 46\%)$ very closely captures the aggregate situation[11].

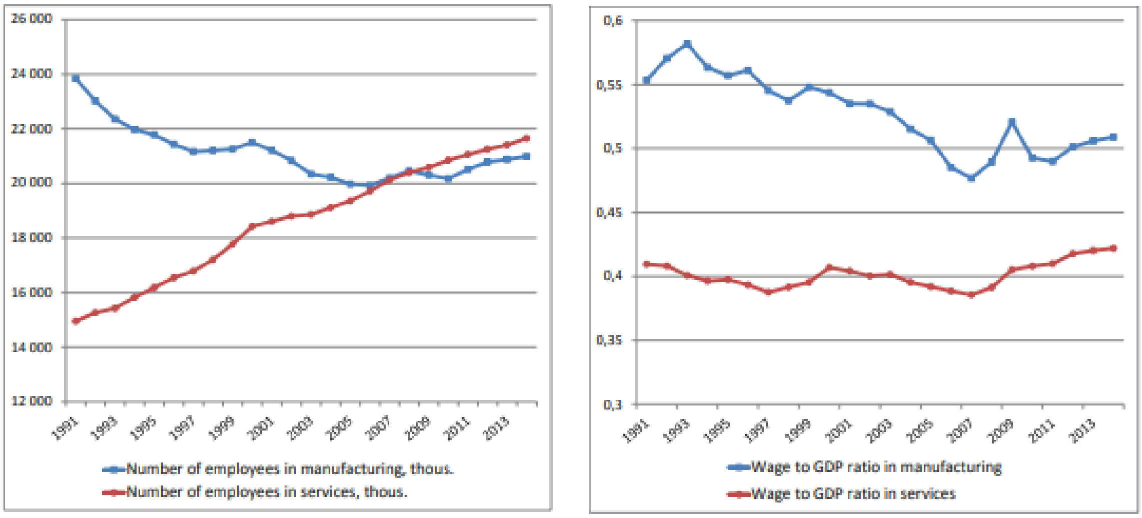
Column (3) presents the coefficients from the probit regression for unemployment with the corresponding marginal effects reported in column (4). We assign unemployed workers to a specific sector based on their prior employment in this sector (in the last five years). We can see that high skill workers have about 5% lower probability of unemployment than low skill workers. Moreover, the risk of unemployment is on average 1.5% lower for native workers compared to immigrants. There are no significant sectoral differences in the unemployment rates. With these estimates we can predict the risk of unemployment and mismatch for all worker groups in our model. Based on the predicted group-specific probabilities of unem-

this margin to match empirical unemployment rates and continue by assuming identical separation rates δ between the two ethnic groups.

[10] Marginal effects are calculated at means (for an average individual in the sample)

[11] The data source is DESTATIS, Statistisches Bundesamt, 2015: Fachserie 18 Reihe 1.2: Volkswirtschaftliche Gesamtrechnungen

Figure 2.1: Left panel: Employment in manufacturing and services. Right panel: Ratio of gross wages to the GDP by sector, data source: DESTATIS



ployment and mismatch we can calculate the values for $\lambda(\theta_j^i)$ and h_{jn}^k based on equations (2.17)-(2.18). Tables 2.2 and 2.3 give the summary of the results for Manufacturing (sector 1) and Services (sector 2) respectively.

Table 2.2: Calibration of labour turnover rates in sector 1: $g_1 = 0.4569$, $\delta = 0.02$

Variable	Target	Parameter value	Variable	Target	Parameter value
Natives $g_{1N}^L/g_1 = 0.6413$			Natives $g_{1N}^H/g_1 = 0.2407$		
u_{1N}^L/g_{1N}^L	0.0663	$\lambda(\theta_1^L) = 0.2817$	u_{1N}^H/g_{1N}^H	0.0222	$\lambda(\theta_1^H) = 0.0797$
			m_{1N}^H/g_{1N}^H	0.1784	$h_{1N}^M = 2.8394$
Immigrants $g_{1I}^L/g_1 = 0.0973$			Immigrants $g_{1I}^H/g_1 = 0.0207$		
u_{1I}^L/g_{1I}^L	0.0826	$h_{1I}^L = 0.7888$	u_{1I}^H/g_{1I}^H	0.0276	$h_{1I}^H = 0.5228$
			m_{1I}^H/g_{1I}^H	0.2968	$h_{1I}^M = 2.3533$

We can see that the job-finding rate in the low skill submarket $\lambda(\theta_1^L)$ is equal to 0.2817. This rate generates the empirically predicted unemployment rate of low skill native workers equal to 6.6%. Concerning employment chances of immigrant workers, we find that the hiring probability in the low skill segment ($h_{1I}^L = 0.7888$) is smaller than 1, which confirms worse employment chances of immigrant workers compared to natives. The situation is more extreme in the high skill submarket, where the employment chances of immigrant workers are almost two times worse ($h_{1I}^H = 0.5228$) than the employment chances of native workers. The job-finding rate of high skill workers is relatively low: $\lambda(\theta_1^H) = 0.0797$, but the total flow probability of finding a job for high skill native workers is higher than $\lambda(\theta_1^H)$ and given by $h^M_{1N}\lambda(\theta^L_1) + \lambda(\theta^H_1) = 0.8796$. This job-finding rate replicates the low probability of unemployment for high skill native workers equal to 2.2%. These results indicate that finding a job is relatively easy for high skill workers, however, finding a good match is relatively difficult and even more difficult for immigrant workers. The situation in sector 2 (services) is summarized in table 2.3. The unemployment rates of all worker groups are similar to sector 1 but not the mismatch rates. One can see that the mismatch rate of high skill native workers is only 9.3%, which indicates much better chances of high skill native workers in finding good matches in service occupations, that is $\lambda(\theta^H_2) = 0.1547$. Also the mismatch of immigrant workers in services is lower than in sector 1 and equal to 17.9%.

Table 2.3: Calibration of labour turnover rates in sector 1: $g_2 = 0.5431$, $\delta = 0.02$

Variable	Target	Parameter value	Variable	Target	Parameter value
Natives $g^L_{2N}/g_2 = 0.4426$			Natives $g^H_{2N}/g_2 = 0.4882$		
u^L_{2N}/g^L_{2N}	0.0659	$\lambda(\theta^L_2) = 0.2837$	u^H_{2N}/g^H_{2N}	0.0213	$\lambda(\theta^H_2) = 0.1547$
			m^H_{2N}/g^H_{2N}	0.0932	$h^M_{2N} = 2.6929$
Immigrants $g^L_{2I}/g_2 = 0.0394$			Immigrants $g^H_{2I}/g_2 = 0.0298$		
u^L_{2I}/g^L_{2I}	0.0793	$h^L_{2I} = 0.8188$	u^H_{2I}/g^H_{2I}	0.0283	$h^H_{2I} = 0.4939$
			m^H_{2I}/g^H_{2I}	0.1792	$h^M_{2I} = 2.1543$

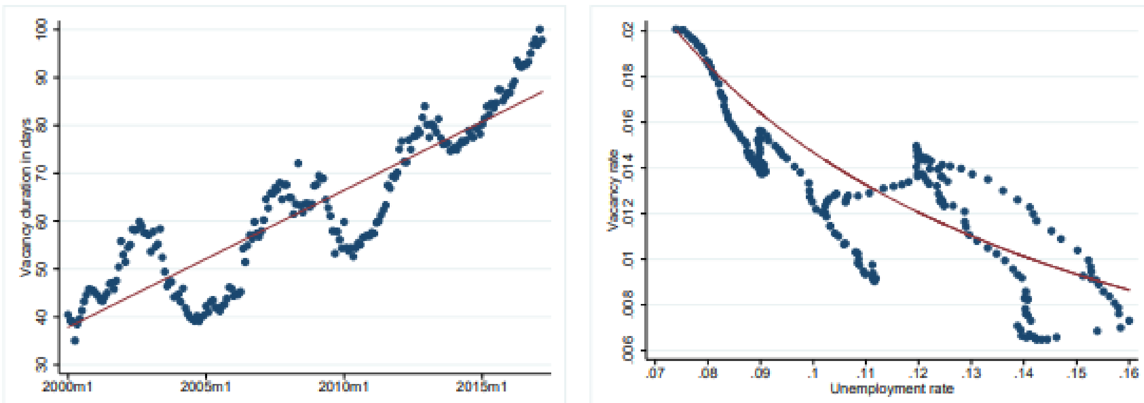
The next step includes the estimation of the matching function $m(s^i_j, v^i_j)$. We assume a Cobb-Douglas form for the matching function given as follows:

$$m(s^i_j, v^i_j) = \lambda_0 (s^i_j)^\eta (v^i_j)^{1-\eta} \tag{2.21}$$

and since $q(\theta^i_j) = \frac{m(s^i_j, v^i_j)}{v^i_j}$ and $\theta^i_j = \frac{v^i_j}{s^i_j}$ we need the values of variables $q(\theta^i_j)$and θ^i_j to carry out our calibration. These values are used to determine parameters λ_0 and η. For estimating these two parameters we use statistical information of the Federal Employment Office (Bundesagentur für Arbeit) for the period between January 2000 and March 2017. This data includes information on the absolute number of unemployed, vacancies and vacancy durations which are not available in the GSOEP survey. This yields 207 monthly observations of the unemployment rate, vacancy rate and the average vacancy duration (in days). These variables are illustrated in figure 2.2. The left panel of this figure shows a sharp increase of the average vacancy duration in the last 17 years. Whereas it was only 35 days in the year 2000, it almost tripled and reached a level 100 days by 2017. This is important for our analysis because adding new immigrants to the labour market of 2011 with moderate labour shortage would produce different results than adding new immigrant workers to the labour market of 2000 with a shortage of vacancies. The average vacancy duration in the year 2011 was 63.7 days.

Using this data we find the aggregate job-filling rate $\bar{q}(\theta)$ as the inverse of the vacancy duration (expressed in quarters) and estimate the following regression $\ln \bar{q}(\theta_t) = cst - \eta \ln \theta_t + \epsilon_t$.

Figure 2.2: Left panel: Vacancy duration between January 2000 and March 2017. Right panel: Beveridge curve in Germany, data source: Bundesagentur für Arbeit



This regression gives us a value of the slope parameter η equal to 0.4607. The corresponding Beveridge curve for Germany is illustrated on the right panel of figure 2.2. Our regression provides a good fit of the negative relationship between unemployment and vacancies in Germany. Further, note that the average job-filling rate $\bar{q}(\theta_j^i)$ in submarket i, j is a product of the contact rate $q(\theta_j^i)$ and the average continuation rate in a respective submarket:

$$\begin{aligned} \bar{q}(\theta_j^H) &= \lambda_0(\theta_j^i)^{-\eta}\Big(\frac{u_{jN}^H + m_{jN}^H}{s_j^H} + h_{jI}^H \frac{u_{jI}^H + m_{jI}^H}{s_j^H}\Big) \\ \bar{q}(\theta_j^L) &= \lambda_0(\theta_j^i)^{-\eta}\left(\frac{u_{jN}^L}{s_j^L} + h_{jI}^L \frac{u_{jI}^L}{s_j^L} + h_{jN}^M \frac{u_{jN}^H}{s_j^L} + h_{jI}^M \frac{u_{jI}^H}{s_j^L}\right) \end{aligned}$$

Let $v = v_1^L + v_1^H + v_2^L + v_2^H$ denote the total number of vacancies in the economy. The aggregate job-filling rate $\bar{q}(\theta)$ is then a weighted average of the four job-filling rates in the respective submarkets $\bar{q}(\theta_j^i)$:

$$\bar{q}(\theta) = \frac{v_1^L}{v}\bar{q}(\theta_1^L) + \frac{v_1^H}{v}\bar{q}(\theta_1^H) + \frac{v_2^L}{v}\bar{q}(\theta_2^L) + \frac{v_2^H}{v}\bar{q}(\theta_2^H)$$

We set the average vacancy duration in the economy $1/\bar{q}(\theta)$ equal to 63.7/92 to express it in quarters and find the multiplier of the matching function $\lambda_0 = 0.5801$ from the above equation. We can then estimate the values of θ_j^i for the four different submarkets as:

Table 2.4: Estimated values of endogenous variables θ_j^i and v_j^i/g_j^i

	Manufacturing		Services	
	Low skill	High skill	Low skill	High skill
$\theta_j^i = \left(\frac{\lambda(\theta_j^i)}{\lambda_0}\right)^{\frac{1}{1-\eta}}$	0.2620	0.0252	0.2654	0.0862

This table shows that market tightness values in low skill submarkets are similar in the two production sectors, but there are large sectoral differences faced by high skill workers, with the market tightness in services being more than three times larger ($0.0862 > 0.0251$). Overall, we can see relatively low values of the market tightness for high skill workers compared to the low skilled. This implies that there are fewer vacancies per searching worker in the high skill submarket. Nevertheless, high skill workers can take low skill jobs as a temporary solution to avoid unemployment and so their unemployment rates are lower compared to the low skilled.

2.4.2 Wages and productivities

In this subsection we calibrate a vector of parameters $\{\beta_j^i, K_j, b_{jn}^i, t\}$ as well as wages and productivities of different worker groups. In order to estimate wage differences we use a Mincer wage regression with a logarithm of gross monthly wages in 2011 as dependent variable (GSOEP data). The estimated coefficients are presented in column (5) of table A1 in the appendix. High skill workers earn about 50% more than low skill workers, however, most of this return (43%) is lost if high skill workers are mismatched and perform low skill jobs. Further, native workers earn about 7% higher wages than immigrant workers but it is clear that this difference is between observationally identical workers and it is larger (15%) once we take into account that immigrant workers are less educated on average and more likely to be mismatched. This native/immigrant wage gap is somewhat smaller than the numbers reported in other studies for Germany (it is 22% in Nanos and Schluter (2014) and 23% in Dustmann et al. (2010)) because of a broader definition of immigrant workers in our work, which includes German citizens with immigration background, whose wages are closer to the wages of native workers. There are no significant wage differences between the two sectors for observationally identical workers. We use this regression to obtain predicted wage differences between all worker groups.

Having obtained information on wages, we aim to uncover the underlying productivities of workers $p_j y_{jn}^i$. To do this we make use of the aggregate data on wages and GDP for Germany and calculate a ratio between the nominal gross wage and the GDP[12]. Figure 2.1 shows that there are systematic differences between the two sectors with respect to the share of output accruing to workers. In service occupations this difference was stable around 40% in the recent 25 years but it was decreasing in manufacturing which could be an indication of decreasing importance of labour unions in this sector. The data implies that in 2011 the ratio between the average gross wage and GDP in manufacturing was equal to 49% whereas it was lower in services and equal to 41%. This gives us the following two relationships $\bar{w}_1 = 0.49 p_1 \bar{y}_1$ and $\bar{w}_2 = 0.41 p_2 \bar{y}_2$, where $\bar{w}_j$ is an average wage in sector j and $p_j \bar{y}_j$ is an average productivity given by:

$$\bar{w}_j = \frac{e_{jN}^L}{e_j} w_{jN}^L + \frac{e_{jI}^L}{e_j} w_{jI}^L + \frac{m_{jN}^H}{e_j} w_{jN}^M + \frac{m_{jI}^H}{e_j} w_{jI}^M + \frac{e_{jN}^H}{e_j} w_{jN}^H + \frac{e_{jI}^H}{e_j} w_{jI}^H \tag{2.22}$$

$$\bar{y}_j = \frac{e_{jN}^L}{e_j} y_{jN}^L + \frac{e_{jI}^L}{e_j} y_{jI}^L + \frac{m_{jN}^H}{e_j} y_{jN}^M + \frac{m_{jI}^H}{e_j} y_{jI}^M + \frac{e_{jN}^H}{e_j} y_{jN}^H + \frac{e_{jI}^H}{e_j} y_{jI}^H \tag{2.23}$$

[12]The data source is DESTATIS, Statistisches Bundesamt, 2015: Fachserie 18 Reihe 1.2: Volkswirtschaftliche Gesamtrechnungen

Here $e_j = e^L_{jN} + e^L_{jI} + m^H_{jN} + m^H_{jI} + e^H_{jN} + e^H_{jI}$ – is total employment in sector j. To estimate the remaining parameters β^i_j and rK_j we need data on the tax rate and the unemployment replacement rate in Germany. The average ratio between the net wage after taxes and the gross wage in our sample is equal to 65%. Hence we set $t = 0.35$ for all submarkets. Furthermore, we set the net unemployment benefit replacement rate z equal to 0.612, this is an average value for a married couple with 2 children calculated by the OECD in 2011 for Germany[13], so that $b^L_{jn} = 0.612 w^L_{jn}(1-t)$. For high skill workers we use the average wage in mismatch w^M_{jn} and proper employment w^H_{jn}. In order to calibrate the flow recruitment costs we rely on recent data by Rebien et al. (2017), who report that the average recruitment cost per low skill vacancy in Germany is 460, whereas the cost of filling a high skill vacancy is 2258. Note that our cost parameters γ^i_j are measured per unit of time (one quarter). To account for that we calculate an average cost of filling of a vacancy, which is the cost per unit time γ^i_j multiplied by the average duration of a vacancy $1/\bar{q}(\theta^i_j)$, that it: $\gamma^L_j/\bar{q}(\theta^L_j)$ in the low skill submarket and $\gamma^H_j/\bar{q}(\theta^H_j)$ in the high skill submarket. Thus we set $\gamma^L_j/\bar{q}(\theta^L_j)$ equal to the normalized value of 460 and $\gamma^H_j/\bar{q}(\theta^H_j)$ equal to the normalized value of 2258 in each of the two production sectors.

Consider sector $j = 1, 2$. In each of the two sectors we have six wage equations given by (2.19) and (2.20), one ratio between the average wage and the GDP given above and two free-entry conditions $V^L_j = K_j$ and $V^H_j = K_j$. With these nine equations we can calibrate the two bargaining power parameters β^L_j and β^H_j, the entry cost K_j and six productivity variables $p_j y^k_{jn}$, $k = L, M, H$. Our results are summarized in tables 2.5 and 2.6. We normalize the marginal product of low skill immigrant workers in services to 1, that is $p_2 y^L_{2I} = 1$, which corresponds to the monetary value 5830. For example, table 2.5 shows that the wage of low skill native workers in manufacturing is 0.38, this means 0.38·5830=2215.

Table 2.5: Estimated values of endogenous variables $p_j y^i_{jn}$, w^i_{jn} in sectors 1 and 2

	Low skill		High skill			
			Match		Mismatch	
	Immigr.	Native	Immigr.	Native	Immigr.	Native
$p_1 y^k_{1n}$	0.8244	0.8327	1.0956	1.0908	0.7346	0.7899
w^k_{1n}	0.3684	0.3800	0.6329	0.6398	0.3016	0.3548
$p_2 y^k_{2n}$	1.000	1.0448	1.2418	1.2875	1.0006	1.0079
w^k_{2n}	0.3119	0.3580	0.5513	0.6081	0.3361	0.3529

We can see that high skill workers in manufacturing have the highest bargaining power $\beta^H_1 = 0.8364$, it is also reflected in the highest wages of immigrant and native workers in this group (0.6329 and 0.6398 respectively). This is despite the fact that high skill workers in manufacturing are less productive on average than workers with similar skills employed in service occupations, compare, for example, the productivity of native workers in the two sectors: $p_2 y^H_{2N} = 1.2875$ and $p_1 y^H_{1N} = 1.0908$. The reason for lower wages in services is a lower bargaining power $\beta^H_2 = 0.6462$. This finding stems from the empirical evidence that

[13] Data extracted on 24.07.2017 from OECD.Stat

Table 2.6: Estimated parameter values rK_j, β_j^i, γ_j^i

	Manufacturing $rK_1 = 0.4358$		Services $rK_2 = 0.6568$	
	Low skill	High skill	Low skill	High skill
β_j^i	0.4566	0.8364	0.3073	0.6462
γ_j^i	0.0984	1.1545	0.1195	0.6602

service workers get a lower fraction of output produced in their sector. So even though trade unions in manufacturing were losing their bargaining power in the recent decade, our results indicate that they are still stronger than the unions of service workers. Low skill workers have a lower bargaining power with the estimated values $\beta_1^L = 0.4566$ and $\beta_2^L = 0.3073$. This is similar to other studies, for example, Cahuc et al. (2006) find no significant power for intermediate and low skill workers and modestly positive bargaining power for high skill workers in France.

2.4.3 Production function and preference parameters

As a benchmark production function we first consider the limiting case $\rho \to 1$, so the aggregate production function takes the Cobb-Douglas form:

$$Y_j = \left(e_{jI}^L + \psi_{jN}^L e_{jN}^L + \psi_{jI}^M m_{jI}^H + \psi_{jN}^M m_{jN}^H\right)^{\chi_j} \left(e_{jI}^H + \psi_{jN}^H e_{jN}^H\right)^{1-\chi_j}$$

A more general case with $\rho > 1$ is treated further in section 2.6.3. Let Γ_j be the ratio between the high skill labour input and the low skill, that is:

$$\Gamma_j = \frac{e_{jI}^H + \psi_{jN}^H e_{jN}^H}{e_{jI}^L + \psi_{jN}^L e_{jN}^L + \psi_{jI}^M m_{jI}^H + \psi_{jN}^M m_{jN}^H}$$

The marginal products of different worker groups are then given by:

$$y_{jI}^L = \chi_j(\Gamma_j)^{1-\chi_j} \qquad y_{jI}^H = (1-\chi_j)(\Gamma_j)^{-\chi_j} \tag{2.24}$$
$$y_{jN}^L = \chi_j\psi_{jN}^L(\Gamma_j)^{1-\chi_j} \qquad y_{jN}^H = (1-\chi_j)\psi_{jN}^H(\Gamma_j)^{-\chi_j} \tag{2.25}$$
$$y_{jI}^M = \chi_j\psi_{jI}^M(\Gamma_j)^{1-\chi_j} \qquad y_{jN}^M = \chi_j\psi_{jN}^M(\Gamma_j)^{1-\chi_j} \tag{2.26}$$

In this subsection we aim to determine a vector of remaining parameters $\{\chi_j, \psi_{jn}^k, a_1, \sigma\}$. We start by obtaining parameters of the production function. This goal can be achieved by using equations (2.24)-(2.26) for the marginal productivities of workers $p_j y_{jn}^i$. Then we can solve the system of 12 equations (2.24)-(2.26) to identify 10 parameters $\{\chi_j, \psi_{jN}^L, \psi_{jI}^M, \psi_{jN}^M, \psi_{jN}^H\}$ and two prices p_1 and p_2. This gives us $p_1 = 1.5939$, $p_2 = 2.2393$, $\chi_1 = 0.7306$ and $\chi_2 = 0.4699$. The remaining 8 parameters are summarized in table 2.7. Variable χ_1 is relatively high and reflects the fact that manufacturing is a low skill biased sector, in contrast, χ_2 is lower but close to 0.5, indicating that services is a more balanced sector and has similar proportions of high and low skill workers. Recall that the productivity of low skill immigrant workers in services $p_2 y_{2I}^L$ is normalized to 1. Given that the price $p_2 = 2.2393$ we can see that these workers produce 0.45 units of the low skill intermediate good in services. Firms sell these units at the price 2.2393 per unit to the final goods producers, which explains the monetary value of the productivity $p_2 \cdot y_{2I}^L = 0.45 \cdot 2.2393 = 1$.

Table 2.7: Estimated values of productivity parameters ψ_{jn}^k in sectors 1 and 2

	Low skill		High skill			
			Match		Mismatch	
	Immigr.	Native	Immigr.	Native	Immigr.	Native
ψ_{1n}^k	–	1.0101	–	0.9956	0.8912	0.9582
ψ_{2n}^k	–	1.0448	–	1.0367	1.0006	1.0079

Based on the estimated parameters of the production function and the numbers of employed workers we can find the model-implied fraction of services in the total GDP ($p_2Y_2/(p_1Y_1 + p_2Y_2)$), which is equal to 0.6112. The elasticity of substitution between manufactured goods and services σ we set equal to 0.3 as in Pissarides and Ngai (2004). With these parameters and the aggregate equilibrium condition $C_2 = Y_2$ we get:

$$0.6112 = \frac{p_2Y_2}{p_1Y_1 + p_2Y_2} = \frac{p_2\left(\frac{p_2}{a_2}\right)^{-\sigma}}{p_1\left(\frac{p_1}{a_1}\right)^{-\sigma} + p_2\left(\frac{p_2}{a_2}\right)^{-\sigma}} \quad \Rightarrow \quad a_1 = 0.3286$$

Finally, we find that the lump-sum transfer from the budget, guaranteeing a balanced budget constraint, is equal to $T = 0.1436$. Table A6 in the appendix contains a full list of all parameter values that we use in the calibration and their explanations.

2.5 Results

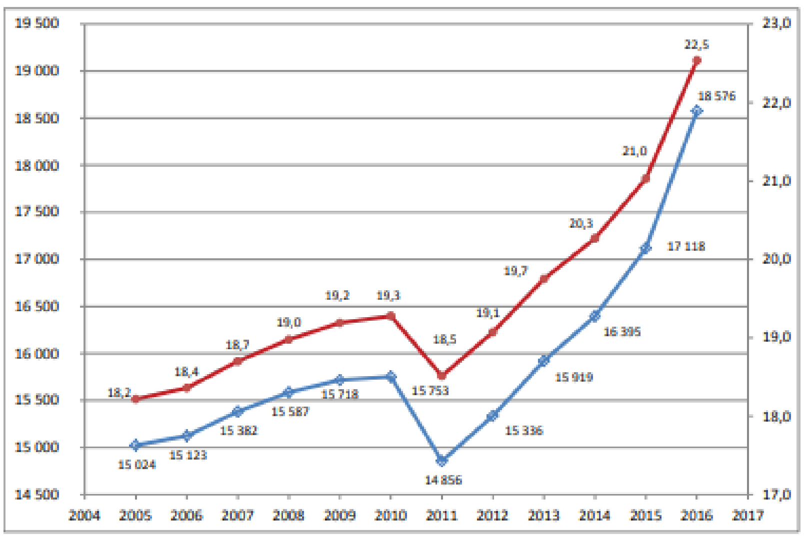
2.5.1 Immigration inflow

In this section we analyze the effect of the post-crisis immigration to Germany that took place in the period 2012-2016. Figure 2.3 shows an absolute number and a fraction of immigrant individuals living in Germany[14]. The data is between 2005 and 2016. A sharp drop in both variables observed in 2011 is explained by the population census which revealed a lower number of immigrants in the population compared to the projected number based on the registered inflow and outflow of immigrants. This is because not all permanent exits of

[14]This number includes foreign workers, individuals who acquired German citizenship at some point of their life as well as their children who obtained German citizenship from the birth. So it is higher than the fraction of immigrants in our sample since individuals having German citizenship from the birth are classified as natives in our sample even if their parents had other nationality but they are classified as individuals with immigration background in the official statistics.

foreign citizens are reported and registered in the official statistics. This means the numbers before and after 2011 are not directly comparable. According to the population census from 2011 the number of immigrants comprised 14856 thousands individuals, which corresponds to 18.5% of the total population. Since 2011 the number of immigrants was gradually rising and reached the level 18576 thousands in 2016, which corresponds to 22.5% of the total population. Due to the large inflow of refugees, the net inflow of immigrant workers in 2015 was equal to 723 thousands and 1458 thousands in 2016. Note that there was a delay in the registration of refugees, so that some of the individuals who moved to Germany in 2015 were officially registered only in 2016. Comparing the numbers in 2011 and 2016 we get the rise in immigration equal to 25%.

Figure 2.3: Absolute numbers of immigrant workers (left scale) and their fraction as % of the total population (right scale). Source: DESTATIS, Bevölkerung mit Migrationshintergrund – Ergebnisse des Mikrozensus, Fachserie 1, Reihe 2.2



The fraction of immigrants in our sample is 1307/14282 = 9.1%. With this initial situation, raising the number of immigrants by 25% implies that we add 327 new immigrant workers to the labour market. We assume that the immigration inflow is sector-neutral and that new immigrant workers are low skilled. The reason is twofold, one the one hand, reliable data on the skill composition of recent immigrants and refugees in Germany is not available yet, on the other hand, it takes time till the degrees of immigrant high skill workers are confirmed and recognised. In some cases (e.g. medicine) it is also a costly process and requires additional training and examinations. Therefore, even in the long run not all high skill workers apply for the recognition of their degrees and remain in the low skill segment of the labour market (downgrading upon arrival). Given that the inflow of new workers is equal to 327, we add 221 immigrant workers to sector 1 (manufacturing) and the remaining 106 immigrants to sector 2 (services). The underlying assumption for the sector-neutral immigration is that new workers reveal the same sector-sorting pattern as previous generations of immigrants with 2.08 times more workers in manufacturing compared to services. We do not distinguish between labour migrants and refugees and consider them as one group. Even though some studies (e.g. Dustmann et al. (2017)) indicate worse labour market outcomes of refugees compared to labour migrants, we take into account strong policy changes[15] that took place in Germany in 2015 and 2016, according to which substantial financial resources are invested into the integration of recent refugees into the labour market, so one can expect that the integration of new refugees will be faster and more successfull than it was in the past. Further, we decompose the total effect of immigration on wages and unemployment in the following way:

- **The effect of labour supply** $\{u|y, v, p\}$. In this step we keep constant all productivities y^k_{jn}, vacancies v^i_j, prices p_j and the lump-sum transfer T. Thus the only effect of immigration on unemployment is due to the rise in the number of searching workers. A higher number of low skill immigrants is likely to have a negative impact on the employment chances of incumbent low skill workers with a further negative effect on their wages. But also high skill workers may be affected via the probability of mismatch employment.

- **The effect of productivity** $\{u, y|v, p\}$. In this step we allow for a change in the marginal productivities of workers y^k_{jn}, as well as wages and unemployment but we keep constant vacancies v^i_j, prices p_j and the lump-sum transfer T. We expect that a larger number of low skill workers will reduce the marginal productivity of incumbent low skill employees and increase the marginal productivity of high skill employees. Changes in productivities are translated into changes in wages. However, by construction, there is no additional effect on unemployment at this step since the number of vacancies remains unchanged.

- **The effect of labour demand** $\{u, y, v|p\}$. At this step we allow for endogenous vacancies v^i_j, productivities y^k_{jn}, wages and unemployment rates but we keep constant output prices p_j and the lump-sum transfer T. Consider an increase in the number of low skill immigrants. Hiring low skill workers becomes easier for firms, which should lead to more vacancies. This is an outward shift of the Beveridge curve. But if employee's productivity is falling due to immigration, this will have a negative effect on profits, the number of vacancies and the market tightness. In addition, there can be a positive spill-over from the labour market for high skill workers since their productivity is predicted to rise. So the overall effect on the unemployment of low skill workers is ambiguous and should be estimated numerically.

- **Aggregate supply and demand** $\{u, y, v, p\}$. The only variable which remains fixed at this step is the lump-sum transfer from the budget T. All other variables change endogenously in response to an inflow of immigrant workers. On the one hand, many of the new immigrant workers will find jobs in the long run which is associated with a rise in total output supply. This change is likely to be asymmetric between the two sectors as low skill workers are a dominant production factor in manufacturing, whereas high

[15] For example, Asylum package I from the 24th of October 2015 and Asylum package II from the 17th of March 2016. According to the first reform package refugees with good staying perspectives can attend specialised German language courses in their profession (e.g. German for engineers, German for medical personnel), these courses are organised in cooperation with the Federal Employment Agency.

skill workers are relatively more important in services. On the other hand, immigrant workers will have a positive effect on the demand of both goods, which should have a positive effect on the endogenous price p_2.

2.5.2 Welfare calculation

Next we calculate welfare changes associated with the post-crisis wave of immigrants. Let Σ^i_{jn} denote welfare of person i, n in sector j. Low skill workers can be either employed (with probability e^L_{jn}/g^L_{jn}) or unemployed (with probability u^L_{jn}/g^L_{jn}). The corresponding indirect utilities are $[w^L_{jn}(1-t)+T]/P$ and $[b^L_{jn}+T]/P$. So the average welfare of low skill workers is:

$$\Sigma^L_{jn} = \frac{u^L_{jn}[b^L_{jn}+T]}{g^L_{jn}P} + \frac{e^L_{jn}[w^L_{jn}(1-t)+T]}{g^L_{jn}P}$$

High skill workers can be unemployed, employed in a good match or mismatched. The probability of unemployment is u^H_{jn}/g^H_{jn}, the probability of employment in a good match is e^H_{jn}/g^H_{jn} and the probability of mismatch is m^H_{jn}/g^H_{jn}. The corresponding indirect utilities are then $[b^H_{jn}+T]/P$, $[w^H_{jn}(1-t)+T]/P$ and $[w^M_{jn}(1-t)+T]/P$. Hence the average welfare of high skill workers can be written as:

$$\Sigma^H_{jn} = \frac{u^H_{jn}[b^H_{jn}+T]}{g^H_{jn}P} + \frac{e^H_{jn}[w^H_{jn}(1-t)+T]}{g^H_{jn}P} + \frac{m^H_{jn}[w^M_{jn}(1-t)+T]}{g^H_{jn}P}$$

To measure aggregate welfare effects of immigration we define two new variables Σ and $\tilde{\Sigma}$. $\tilde{\Sigma}$ refers to ex-post welfare of a *new representative worker* based on the new distribution $\tilde{g}^i_{jn}$. Whereas Σ refers to ex-post welfare of a *representative incumbent worker* keeping the distribution of workers across demographic groups g^i_{jn} fixed. Given these definitions we get:

$$\Sigma = \Sigma^L_{1I}g^L_{1I} + \Sigma^L_{1N}g^L_{1N} + \Sigma^H_{1I}g^H_{1I} + \Sigma^H_{1N}g^H_{1N} + \Sigma^L_{2I}g^L_{2I} + \Sigma^L_{2N}g^L_{2N} + \Sigma^H_{2I}g^H_{2I} + \Sigma^H_{2N}g^H_{2N}$$
$$\tilde{\Sigma} = \Sigma^L_{1I}\tilde{g}^L_{1I} + \Sigma^L_{1N}\tilde{g}^L_{1N} + \Sigma^H_{1I}\tilde{g}^H_{1I} + \Sigma^H_{1N}\tilde{g}^H_{1N} + \Sigma^L_{2I}\tilde{g}^L_{2I} + \Sigma^L_{2N}\tilde{g}^L_{2N} + \Sigma^H_{2I}\tilde{g}^H_{2I} + \Sigma^H_{2N}\tilde{g}^H_{2N}$$

If Σ^0 denotes ex-ante welfare of a representative worker before the new immigration wave, then the change in welfare can be calculated as $(\tilde{\Sigma}-\Sigma^0)/\Sigma^0$ for the new representative worker and $(\Sigma-\Sigma_0)/\Sigma_0$ for the representative incumbent worker. Note that these percentage changes in welfare are identical to the equivalent variation (EV) measure expressed as a percentage of ex-ante income. This is because indirect utility can be expressed as real income, so that:

$$\Omega(P_0, M^{0i}_{jn}(1+EV)) = \frac{M^{0i}_{jn}(1+EV)}{P_0} = \frac{M^{1i}_{jn}}{P_1} = \Omega(P_1, M^{1i}_{jn}) \quad \Rightarrow \quad EV = \frac{M^{1i}_{jn}/P_1}{M^{0i}_{jn}/P_0} - 1$$

where M^{0i}_{jn}/P_0 is the expected real income of worker $\{i, j, n\}$ before the change and M^{1i}_{jn}/P_1 is the expected real income of this worker after the change.

Next we calculate the welfare of firms and start by considering the submarket for high skill workers. We follow the approach of Acemoglu and Shimer (1999), who calculate the welfare of firms as a total number of new hires (per period) multiplied by the present value of profits and minus the cost of capital. For high skill workers this means:

$$\underbrace{\lambda(\theta_j^H)(u_{jN}^H + m_{jN}^H)}_{\text{new hires of natives}} \cdot \underbrace{\left[\frac{p_j y_{jN}^H - w_{jN}^H - rK_j}{r+\delta}\right]}_{\text{PV of profits by natives}} + \underbrace{\lambda(\theta_j^H)(u_{jI}^H + m_{jI}^H)h_{jI}^H}_{\text{new hires of immigrants}} \cdot \underbrace{\left[\frac{p_j y_{jI}^H - w_{jI}^H - rK_j}{r+\delta}\right]}_{\text{PV of profits by immigrants}} - \underbrace{(rK_j + \gamma_j^H)v_j^H}_{\text{capital cost}}$$

The first term in the above equation is a total number of hired native workers (per period) coming from unemployment or mismatch multiplied by the present value of profits generated by these workers. The second term is a total number of hired immigrant workers (per period) multiplied by their present value of profits. Note that each of the two present values includes the capital cost $-rK_j$. This is intuitive, since in our model firms pay an upfront cost K_j upon the entry, but this is equivalent to paying a flow cost $-rK_j$ in every period of time and in all states. Thus the flow cost $-rK_j$ is paid by filled jobs and open vacancies, which is the last term in the above expression. In contrast, the hiring cost γ_j^H is only paid when the firm is searching for a worker. Rearranging this expression we get:

$$\begin{aligned} & v_j^H\left(\frac{\lambda(\theta_j^H)(u_{jN}^H + m_{jN}^H)s_j^H}{v_j^H s_j^H}(J_{jN}^H - K_j) + \frac{\lambda(\theta_j^H)(u_{jI}^H + m_{jI}^H)h_{jI}^H s_j^H}{v_j^H s_j^H}(J_{jI}^H - K_j) - rK_j - \gamma_j^H\right) \\ = \; & v_j^H\left(q(\theta_j^H)\frac{u_{jN}^H + m_{jN}^H}{s_j^H}(J_{jN}^H - K_j) + q(\theta_j^H)h_{jI}^H\frac{u_{jI}^H + m_{jI}^H}{s_j^H}(J_{jI}^H - K_j) - rK_j - \gamma_j^H\right) = 0 \end{aligned}$$

The free-entry condition (2.11) implies that firms enter submarket $\{H, j\}$ as long as expected profits V_j^H are higher than the cost K_j, thus in the equilibrium the welfare of firms producing high skill intermediate goods is equal to zero due to the free-entry condition. The reason is that strong competition between firms dilutes profits and leads to this result irrespective of the search frictions. It is straightforward to show that the free-entry condition in the low skill submarket also implies that the present value of firm profits is equal to the total cost and so the welfare of firms in the low skill submarket is also zero. Finally, note that the profits of final goods producers are also zero, because they pay the marginal product for all intermediate goods.

2.5.3 Numerical results

In this subsection we analyze the implications of a 25% increase in low skill immigration. To keep the rise in immigration sector-neutral we add 221 workers to the manufacturing sector and 106 workers to services, so the ratio of employment numbers in the two sectors remains the same $(635+221)/(305+106) = 2.08$. We conduct our analysis according to the aforementioned steps.

- In this step we analyze the implications of a change in labour supply, that is $\{u|y, v, p\}$. The corresponding rows of table A2 in the appendix show that there is a moderate rise in unemployment of low skill workers since they are facing more competition for a fixed number of vacancies. Immigrant low skill workers suffer a stronger increase in unemployment than native workers especially in manufacturing, where the unemployment of low skill immigrant workers is increasing from 8.26% to 8.66%. This is because relatively many new migrants are searching for jobs in manufacturing. As expected worse outside opportunities are translated into lower wages of low skill workers, but the effect is quantitatively small. High skill workers are also affected, their mismatch rate is reduced due to the stronger competition between workers in the low skill submarket. However, all those who were earlier mismatched remain unemployed in the new steady state. For example, the mismatch rate of high skill workers in manufacturing falls by 0.0013 but the unemployment rate is increasing by 0.0013.

- In this step we estimate the response of productivities, that is $\{u, y|v, p\}$. First, note that there is no direct effect on unemployment or mismatch since vacancies are still fixed and the change in labour supply was already accounted for. As expected, low skill immigration leads to lower productivity of low skill workers and a higher productivity of high skill workers. These changes are translated into wages. Specifically, we find that high skill natives employed in manufacturing gain most from low skill immigration at this step. Their wages are expected to rise by 0.0312 (from 0.6398 to 0.6710), which is approximately +4.9%. The gain for high skill immigrant workers in this sector is smaller (0.0303) compared to natives due to the higher probability of mismatch employment.

- In the next step we allow for an endogenous response in vacancies, that is $\{u, y, v|p\}$. First, consider manufacturing. Due to the higher productivity of high skill workers in this sector, firms expect higher profits and create more vacancies, this is the positive job-creation effect of immigration. So the mismatch of high skill workers falls, for example, the mismatch rate of high skill immigrants in manufacturing is reduced from 29.69% down to 28.52%. Due to this effect, there is also a positive spillover to the labour market for low skill workers: since there are more employed high skill workers, the drop in the productivity of the low skilled is less pronounced. So both worker types gain from a more intensive job-creation in the high skill sub-market. For example, the rise in the unemployment rate of low skill immigrant workers in manufacturing is reduced from +0.0040 in the first step down to only +0.0017 with the positive effect of job creation.

  The situation is different in services where there is a larger proportion in high skill labour and the positive spillover from the high skill submarket is relatively weak. Since low skill workers become less productive, firms reduce job creation in the low skill submarket and there is a further increase in the unemployment rates of low skill workers. For example, the unemployment rate of low skill native workers in increasing from +0.0016 in the first step to +0.0022. Overall, we can see that the two sectors are adversely affected at this step due to the different proportions of high and low skill labour. The effects on wages are rather small.

- In this step we analyze the implications of aggregate supply and demand in services (non-tradable), that is $\{u, y, v, p\}$. On the one hand, a higher absolute number of employees leads to more output in both production sectors but there is a larger increase in manufactured output. The horizontal supply curve in sector 2 is shifting upwards on figure 2.4. The reason is that immigrant workers are overrepresented in manufacturing jobs compared to services and we assume that the distribution of new immigrants will be similar to the past pattern. This could be because service jobs are communication intensive and there is a natural language disadvantage faced by the foreign population. Higher output and, therefore, higher income in both sectors implies higher demand for goods and services, so the downward-sloping demand curve in sector 2 is also shifting upwards on figure 2.4. Recall that on average workers spend 61% of their income on services, so there is an overproportional increase in the demand for services compared to manufacturing. Taking both effects together we find that the price p_2 is increasing up to the level 2.3314 (see table 2.8). This means that stronger demand for services is dominating a moderate increase of service output. Higher price p_2 implies higher nominal productivity of workers in services and generates a strong positive job creation effect in service occupations. Unemployment of all worker groups employed in services is falling compared to the pre-immigration level and their nominal wages are increasing.

Figure 2.4: Equilibrium in sector 2 before and after the new immigration wave. Output is measured on horizontal axis with an initial level set to 1.

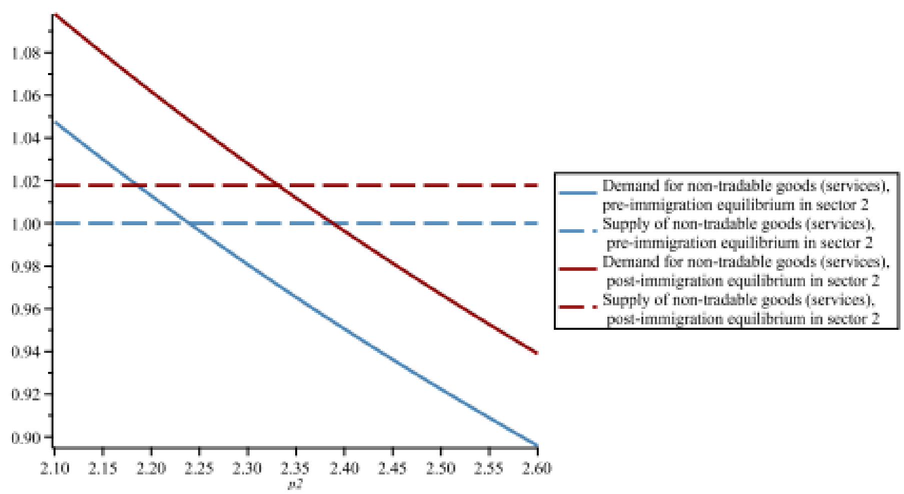


Table 2.8: Sector-specific variables, 25% increase in low-skill immigration

	p_2	θ_1^L	θ_1^H	θ_2^L	θ_2^H	T
Initial values	2.2393	0.2620	0.0252	0.2654	0.0862	0.1436
u, y, v, p, T	2.3314	0.2517	0.0277	0.3464	0.1019	0.1519

The last rows of table A2 (see appendix) show changes in Σ_{jn}^i for all demographic groups. Low skill workers in manufacturing lose welfare, since their unemployment rates are higher and their nominal wages fall. In addition, higher price p_2 reduces their level of consumption. Specifically, the drop in welfare of low skill workers in manufacturing is equal to 3.3%. The loss of high skill workers in manufacturing is smaller and equal to 0.3%. Even though their productivity is increasing in response to low skill immigration, their real income is reduced due to the higher price index P. Low skill workers in services gain welfare (+2.9%), but their gains are smaller than the gains of high skill workers in this sector (+4.7%).

Table 2.9: Changes in aggregate welfare, 25% increase in low skill immigration

	Unbalanced budget (T - fixed)	Balanced budget (new T)
Welfare change $(\Sigma - \Sigma^0)/\Sigma^0$ (representative incumbent worker, g^i_{jn} - fixed)	+1.19%	+3.04%
Welfare change $(\tilde{\Sigma} - \Sigma^0/\Sigma^0)$ (representative new worker, new g^i_{jn})	+0.78%	+2.63%

Based on equations from section 2.5.2, we find that the average welfare gain of a representative incumbent worker is equal to 1.19% (see table 2.9). Taking into account that the share of low skill workers is increased after the change, the welfare gain of a representative new worker is equal to 0.78%. However, these numbers are not the final estimates of welfare as they are based on a constant nominal lump-sum transfer T. Table 2.9 shows that the new transfer from the public budget T is equal to 0.1519. In real terms this corresponds to $0.1519/P = 0.0388$ where P is the post-immigration price index. Recall that the public transfer T in the initial equilibrium was equal to 0.1436, which is $0.1436/P = 0.0377$ in real terms estimated at the initial price index. So the budget surplus T is increasing after the new immigration wave, both in nominal and real terms. Why is there a higher budget surplus if new immigrant workers are low skilled? To illustrate the answer to this question in more details we have summarized the data on budget revenues and expenses in table 2.10. Considering the initial situation we can see that the average wage of incumbent workers was 0.4557 and their average employment rate was 0.9506. Given the tax rate $t = 35\%$ the total inflow of tax payments to the budget was equal to 0.1516 per person. The unemployment expenditures paid out from the budget were equal to 0.0080, yielding the net surplus of the public budget equal to $T = 0.1516 - 0.0080 = 0.1436$ per person.

Next consider the situation after the immigration wave. In the new post-immigration equilibrium 97.76% of individuals are incumbents and 2.24% are new immigrants. The last two rows of table 2.10 show their financial statements. Since new immigrant workers are low skilled their average wage is lower than the average wage of incumbents ($0.3559 < 0.4813$) and their risk of unemployment is much higher ($0.0794 > 0.0470$). So we can see that new immigrant workers contribute less to the budget revenues per person ($0.1146 < 0.1605$) and receive higher unemployment benefits per person ($0.0111 > 0.0076$). Thus their net contribution is much smaller than the net contribution of incumbent workers $0.1036 < 0.1529$. In a partial equilibrium setting with given wages, prices and employment rates this would imply that adding low skill immigrants will reduce the positive surplus of the budget leading to the lower lump-sum transfer per person T. This situation is different in a general equilibrium setting

Table 2.10: Tax revenues and unemployment benefit expenditures, nominal values

	Tax contributions of employees				Unemployment benefits			T
	Average wage	Average tax	Empl. rate	Tax revenue	Average benefit	Unempl. rate	Benefit expenses	Budget surplus
	w	tw	e	twe	b	u	bu	$twe - bu$
Initial values	0.4557	0.1595	0.9506	0.1516	0.1613	0.0494	0.0080	0.1436
	Post-immigration equilibrium (incumbents = 0.9776, new migrants = 0.0224)							
Incumbents	0.4813	0.1684	0.9530	0.1605	0.1610	0.0470	0.0076	0.1529
New migrants	0.3559	0.1245	0.9206	0.1146	0.1402	0.0794	0.0111	0.1036

where wages, prices and vacancies are endogenous. Table 2.10 shows that per person tranfer T is increasing after the new immigration wave: $T = 0.1529 \cdot 0.9779 + 0.1036 \cdot 0.0224 = 0.1519$. The rise in T is fully attributable to the increase in the net contribution of incumbent workers and this effect is dominating. Their average wage is increasing from 0.4557 to 0.4813 leading to higher tax contributions and lower unemployment benefits per person. This increase is driven by higher wages of workers employed in services and explained by the additional demand for services from new immigrant workers. An interaction between the job creation margin and endogenous price p_2 described above is amplifying the initial increase in demand improving not only the nominal but also the real income of an average incumbent worker and tax revenues. Taking into account the endogenous change in T leads to higher welfare of all demographic groups, so the average welfare gain of incumbents is +3.04% and the average welfare gain of a new representative worker is equal to +2.63%.

2.6 Alternative specifications and robustness checks

2.6.1 Competitive labour market

In this subsection we consider an alternative calibration of our model under the assumption of a competitive labour market without search frictions. In the absence of search frictions wages are equal to the marginal productivities, so we let $w_{jn}^k = p_j y_{jn}^k$. For the purpose of comparability we normalize the productivity of low skill immigrant workers $p_2 y_{2I}^L$ to 0.3120. Recall that it was normalized to 1 in the model with frictions. The advantage of this approach is that nominal wages of all worker groups remain the same and it is easy to compare wage responses in the two model specifications with and without frictions. Moreover, without search frictions all workers find jobs and there is full employment in the competitive equilibrium. So we assume that workers observed in unemployment are voluntary unemployed in the sense of non-participation. Again the advantage of this approach is that initial employment levels are the same in the two models with and without frictions. Given that labour supply is inelastic in our benchmark model and there are no transitions between participation and non-participation, we impose the same assumption on the competitive labour market model without frictions. Mismatched high skill workers observed in low skill occupations are assumed to be voluntarily mismatched, so there is no movement of workers from mismatch into high skill jobs.

Restricting productivity differences between worker groups to be equal to wage differences observed in the data (table A2) we recalibrate a vector of parameters $\{\chi_j, \psi^k_{jn}, a_1\}$. This goal can be achieved by using equations (2.24)-(2.26) for the marginal productivities of workers $p_j y^k_{jn}$. Then we can solve the system of 12 equations (2.24)-(2.26) to identify 10 parameters $\{\chi_j, \psi^L_{jN}, \psi^M_{jI}, \psi^M_{jN}, \psi^H_{jN}\}$ and two prices p_1 and p_2. This gives us $p_1 = 0.8222$, $p_2 = 0.8617$, $\chi_1 = 0.6778$ and $\chi_2 = 0.3911$. The remaining 8 parameters are summarized in the table below:

Table 2.11: Estimated values of productivity parameters ψ^k_{jn} in sectors 1 and 2

	Low skill		High skill			
			Match		Mismatch	
	Immigr.	Native	Immigr.	Native	Immigr.	Native
ψ^k_{1n}	–	1.0317	–	1.0110	0.8189	0.9633
ψ^k_{2n}	–	1.1475	–	1.1029	1.0773	1.1313

This table shows that differences in productivities between workers are more extreme in the model without frictions. The reason is that productivity differences are the same as wage differences in this model. In contrast, allowing for search frictions accounts for the fact that differences in wages are partially explained by differences in the outside options of workers, e.g. that native workers have better chances of finding employment than immigrant workers. So calibrated productivity differences are smaller in the model with search frictions. Note also that both prices p_1 and p_2 are smaller in the competitive labour market, this reflects the fact that the normalized productivity $p_2 y^L_{2I}$ is 0.3120 rather than 1, so the price index P is lower. Combining the fact that nominal wages are the same in the two model specifications but the price index is lower we get higher values of welfare Σ^k_{jn} (real income), this is only due to the rescaling of income levels with a new price index P but the relative ordering of welfare is preserved.

Next we analyze the implications of a 25% increase in low skill immigration in a competitive labour market setting, see table A3 in appendix. We assume the same rate of non-participation (voluntary unemployment) among the new immigrant workers as it is among the incumbent immigrants and add $221 \cdot (1 - 0.0826)$ new immigrants to low skill jobs in sector 1 and $106 \cdot (1 - 0.0793)$ new immigrants to low skill jobs in sector 2. Remaining immigrant individuals ($221 \cdot 0.0826$ and $106 \cdot 0.0793$) are assigned to non-participation. Modeling transitions between non-participation and participation giving rise to the elastic labour supply is beyond the scope of this paper.

The price p_2 is increasing in response to immigration from 0.8617 to 0.9164, which is an increase of 6.35%. The direction of this effect is the same as in the model with a frictional labour market but the relative increase is larger (6.35% vs. 4.1%). The reason is that higher price p_2 in the model with search frictions leads to higher profits of intermediate firms operating in services. Due to the endogenous margin of job creation these firms respond positively to higher demand for services (imposed by the new immigrant individuals) and increase the number of vacancies, so the market tightness is increasing in services in both skill groups. This intensifies transitions from unemployment into employment, so higher employment and output of services are dampening the initial increase in the price p_2. In a competitive labour market model participating new immigrants immediately find jobs since there are no frictions, however, the level of employment is limited from above by the total number of participating workers in the new post-immigration equilibrium. This mechanism reveals important differences in the frictional labour market compared to the competitive setting: (1) unemployment of all worker groups in services is decreasing whereas it is voluntary and fixed in the competitive labour market setting (2) nominal wages of both skill groups in services increase stronger in the presence of frictions due to the fact that their outside opportunities in terms of job finding are improving (3) the price increase p_2 in services is weaker with frictions due to the stronger increase in the production of services. For the first statement compare the wage increase of high skill native workers in services, which was +0.0609 in the benchmark model, while it is only +0.0442 in the competitive labour market setting. Table A3 also shows that workers employed in manufacturing suffer from the stronger increase in the overall price index and their drop in welfare is stronger: −3.09% for native low skill workers while it was −1.25% in the model with search frictions.

Table 2.12: Changes in aggregate welfare, competitive labour market

	Unbalanced budget (T - fixed)	Balanced budget (new T)
Welfare change $(\Sigma - \Sigma^0)/\Sigma^0$ (representative incumbent worker, g^i_{jn} - fixed)	-1.12%	-0.19%
Welfare change $(\tilde{\Sigma} - \Sigma^0/\Sigma^0)$ (representative new worker, new g^i_{jn})	-1.57%	-0.58%

Table 2.12 shows that the average effect of immigration in a competitive labour market model is negative but close to zero and equal to −0.19% once the budget adjustment is taken into account. This effect is lower compared to the model with search frictions and endogenous job creation. Note that the budget surplus is increasing in reponse to immigration once new immigrant workers enter employment, so the public transfer T is increasing from 0.1436 to 0.1480 also in the competitive labour market model. But this increase is almost two times weaker compared to the model with frictions and endogenous job creation (from 0.1436 to 0.1519). To sum up, competitive labour market model with inelastic labour supply doesn't account for the interaction between vacancy creation and endogenous prices of non-tradable goods/services and underestimates the overall impact of immigration, which becomes positive

once this interaction is appropriately accounted for. Alternatively, this interaction could be captured by the endogenous increase in the participation of workers in a setting with elastic labour supply but we leave this task for future research.

2.6.2 Unemployment benefits

In the benchmark model of section 2.5 we assumed that nominal unemployment benefits b^i_{jn} remained fixed and unchanged after the influx of immigrants. This could be the case for long term unemployed receiving unemployment assistance, but it is not a realistic assumption for the short term unemployed, since their benefits are closely linked to their wages prior to unemployment. In this subsection we analyze the opposite extreme case, when unemployment benefits are proportional to former wages. In order to achieve this goal we set a fixed replacement rate for all worker groups equal to z. For low skill workers this means : $b^L_{jn} = zw^L_{jn}(1-t)$. For high skill workers the unemployment benefit is a fixed fraction of the average wage:

$$b^H_{jn} = z(1-t)\Big[\frac{m^H_{jn}}{m^H_{jn}+e^H_{jn}}w^M_{jn} + \frac{e^H_{jn}}{m^H_{jn}+e^H_{jn}}w^H_{jn}\Big]$$

With this modification equation (2.19) for low skill workers can be rewritten as:

$$w^L_{jn} = \frac{\beta^L_j(p_j y^L_{jn} - rV^L_j)(r+\delta+h^L_{jn}\lambda(\theta^L_j))}{(r+\delta)(1-(1-\beta)z)+\beta^L_j h^L_{jn}\lambda(\theta^L_j)}$$

Rewritten equations for wages of high skill workers are omitted for the ease of exposition. Using these equations and $z = 0.612$ produces the same benchmark equilibrium as before. However, the new equilibrium after the inflow of immigrant workers will be different, since nominal unemployment benefits are now endogenous. As before we consider a sector-neutral rise in low skill immigration equal to 25% to guarantee that our results are comparable with the benchmark model in section 2.5. Updated results with endogenous unemployment benefits are summarized in tables 2.13-A4:

Table 2.13: Sector-specific variables, 25% increase in low-skill immigration in the model with endogenous unemployment benefits

	p_2	θ^L_1	θ^H_1	θ^L_2	θ^H_2	T
u, y, v, p, T	2.2393	0.2620	0.0252	0.2654	0.0862	0.1436
u, y, v, p, T	2.3564	0.2555	0.0276	0.3019	0.0977	0.1535

Proportional unemployment benefits amplify any initial change in wages. For example, one can see from table **??** that all worker groups with the exception of low skill workers in sector 1, get higher nominal wages after the inflow of immigrants. This is because any initial increase in wages leads to higher unemployment benefits, which improves the bargaining position of workers and reinforces the rise in wages. Higher wages are beneficial for workers but not for firms. Specifically, the market tightness of low skill workers in sector 2 (θ_2^L) has a more moderate increase up to the level 0.3019 compared to the case of fixed unemployment benefits, where it is rising up to 0.3464 in response to the sector-neutral immigration. This negative effect of proportional unemployment benefits on the job creation implies that the rise in output Y_2 is more moderate compared to the benchmark case. So the price of services p_2 increases stronger and is now equal to 2.3564, while it was 2.3314 in the setting with fixed unemployment benefits. Higher price p_2 is beneficial for all workers employed in services, also low skill workers. On the other hand, it is harmful for low skill workers employed in manufacturing since their consumption and therefore welfare are both reduced. Nevertheless, table 2.14 shows that the overall welfare of workers increases in response to the immigration and the average welfare gain for the same $T = 0.1436$ is equal to 1.75% for the average incumbent worker and 1.33% for the new representative worker. Note that there are opposite effects on high skill workers in sector 1, where immigrant workers are worse off (-0.83%), but native workers are better off ($+0.22\%$). The reason is that immigrant workers in this sector are more likely to be mismatched, so their average wage is more sensitive to changes in the low skill submarket compared to native workers who are rarely mismatched.

Table 2.14: Changes in aggregate welfare, endogenous proportional unemployment benefits

	Unbalanced budget (T - fixed)	Balanced budget (new T)
Welfare change $(\Sigma - \Sigma^0)/\Sigma^0$ (representative incumbent worker, g^i_{jn} - fixed)	+1.75%	+3.95%
Welfare change $(\tilde{\Sigma} - \Sigma^0/\Sigma^0)$ (representative new worker, new g^i_{jn})	+1.33%	+3.53%

Next we consider the implications of immigration for the public budget. On the one hand, unemployment benefits increase in response to higher wages, which is an additional burden for the budget, but on the other hand, higher wages, especially in service occupations, lead to higher tax contributions and reduce the pressure on public finances. Overall, we find that the second effect is dominating and public transfers increase to the level $T = 0.1535$, which is larger than 0.1519 in the setting with fixed unemployment benefits. Taking into account this increase in public transfers, the overall effect from immigration is increased to 3.95% for the average incumbent worker and 3.53% for the new representative worker. Comparing 3.95% with 3.04% in the case of fixed benefits, we conclude that proportional unemployment benefits amplify the positive effect of immigration reported in section 2.5.

2.6.3 CES production technology

In this subsection we consider a different calibration of our model with a more general CES production function as described in section 2.2. Specifically, we take the elasticity of substitution between different skill groups of labour in Germany from the recent study by D'Amuri et al. (2010). They find that $1/\rho = 0.34$ ($\rho = 2.94$), thus the Cobb-Douglas production function implies a lower elasticity of substitution between high and low skill labour compared to the one observed empirically for Germany. In order to address this issue we deviate from the Cobb-Douglas specification and perform a new calibration of our model with $\rho = 2.94$. All other transition parameters $\{r, \delta, h^k_{jn}, \eta, \lambda_0\}$, frictional parameters $\{\beta^i_j, K_j, b^i_{jn}, t\}$ as well as nominal wages, productivities, and public expenditures $\{w^k_{jn}, p_j y^k_{jn}, T\}$ remain the same as in the benchmark calibration. In addition, since variables ψ^k_{jn} reflect ratios between productivities of respective worker groups and productivities of immigrant workers in these groups, these parameters also remain unchanged. The only change in terms of model calibration refers to the two parameters of the production function χ_1 and χ_2, the corresponding fixed price p_1, as well as the share of good 1 in total consumption a_1. Setting, $\rho = 2.94$ and using the new productivity equations from section 2.3 we find the following:

Table 2.15: New calibrated parameters with the CES production function

χ_1	χ_2	p_1	a_1
0.5378	0.4541	1.7948	0.2710

Next we set these parameter values and document the impact of a sector-neutral 25% increase in immigration with the CES production function. Our results are documented in tables 2.16-2.17 and A5.

Table 2.16: Sector-specific variables under CES production function

	p_2	θ^L_1	θ^H_1	θ^L_2	θ^H_2	T
u, y, v, p, T	2.2410	0.2620	0.0252	0.2654	0.0862	0.1436
u, y, v, p, T	2.3329	0.2580	0.0263	0.3576	0.0988	0.1519

These tables reveal the following. If the elasticity of substitution between high and low skill workers is larger ($\rho = 2.94 > 1$) it is easier to substitute workers with different skills for each other. Table **??** shows that this change is beneficial for the low skilled and costly for the high skilled. For example, the rise in wages of all high skill workers in good matches is mitigated, whereas the rise in wages of the low skilled in services is amplified. As before, groups of workers losing from immigration are the low skill workers and mismatched high skill workers in sector 1, however, the drop in their wages is weaker with a higher elasticity of substitution.

When considering welfare, we can see that the increase in the price of services p_2 is similar to the case of a Cobb-Douglas production function. This rise in prices eliminates the welfare gain of high skill workers in manufacturing, so only workers supplying services gain from immigration in terms of welfare. Nevertheless, the overall welfare gain from immigration is positive and equal to 1.15% and 0.75% for the incumbent and new representative worker respectively when the public transfer T is fixed. Allowing for the adjustment in the public budget we find that T increases to the level 0.1519 due to higher taxes. This raises the total welfare gain from immigration to the level 3.01% and 2.61% depending on the reference group. Thus the overall welfare gain remains the same with the CES production technology.

Table 2.17: Changes in aggregate welfare, CES production function

	Unbalanced budget (T - fixed)	Balanced budget (new T)
Welfare change $(\Sigma - \Sigma^0)/\Sigma^0$ (representative incumbent worker, g^i_{jn} - fixed)	+1.15%	+3.01%
Welfare change $(\tilde{\Sigma} - \Sigma^0/\Sigma^0)$ (representative new worker, new g^i_{jn})	+0.75%	+2.61%

2.7 Conclusion

In this study we explored the effects of immigration on the German labour market using a search and matching framework. Within this framework we analyzed the welfare effects of immigration on consumers in Germany. We developed a model with two sectors of production – manufacturing and services – and workers heterogeneous in their skills (low or high), origin (native or immigrant) and the production sector. There are four submarkets where four types of intermediate goods are produced. In each final good sector the low and high skilled intermediate goods are combined to produce the final good using CES production technology. Our model differs from the existing literature as it includes vertical skill mismatch of high skill workers. Our model also considers fiscal redistribution policy to capture the impact of immigration on the public budget. We assume that manufactured goods are traded on international markets and keep the price in manufacturing fixed. In contrast, the price in services is endogenously determined within the model since services are consumed domestically.

For the calibration of parameters we used GSOEP data from 2011 as well as aggregate macroeconomic indicators. We performed a theoretical experiment to analyze the implications of a 25% increase in immigration observed in Germany in the period 2012-2016. Our results show that the overall welfare effect of immigration is positive and estimated at +3%. Considering separate groups, only low skill workers in manufacturing have a lower welfare (−1.2%). All other worker groups, especially, high skill workers in services gain from immigration. This effect is driven by higher internal demand for services, which leads to higher prices of services. The gains of workers employed in service jobs are partially redistributed through the tax system and reduce welfare losses of low skill workers in manufacturing.

We also performed several extensions of our model to compare it with a competitive labour market model and to analyze the effects of proportional unemployment benefits. We find that employment and output in services are increasing stronger in the model with search frictions due to the intensified transitions of workers from unemployment to employment. This means that the gains of workers in services are larger and the price increase is smaller in a labour market model with search frictions. So the average welfare effect is positive in the benchmark model with search frictions, whereas it is close to zero in a competitive labour market framework. Further, our results show that unemployment benefits proportional to wages amplify the positive effect of immigration. Overall, we conclude that accounting for changes in the aggregate supply and demand of the non-tradable good generates additional welfare gains from immigration which were not considered in the related literature.

Chapter 3

Brain drain, informality and inequality: a search-and-matching model for sub-Saharan Africa

This chapter revisits the effect of the brain drain on development and inequality using a two-sector model with formal and informal labor markets. Contrary to existing studies, we use a search-and-matching setting that is consistent with the income and employment patterns of poor countries. Theoretically, the brain drain induces ambiguous welfare effects for those left behind. We thus parameterize our model on 33 sub-Saharan African countries and produce comparative results for each of them. We find that skilled emigration induces heterogeneous welfare losses for the low-skilled population. The size of these losses varies between 1 and 8%, and is influenced by country characteristics such as the productivity gap between sectors and the education technology. The results are fairly robust to identifying assumptions, to the inclusion of technological externalities, and to the endogenization of training decisions.

3.1 Introduction

How does skilled emigration affect development and the welfare of those left behind? This question has been the source of repeated and controversial statements in the literature for the last fifty years or so. The reasons why skilled emigration can hurt development in poor countries are well established. Nearly one in four college-educated adults born in a low-income country now live in the developed world; this human capital flight may deprive the sending country from the necessary resources to drive economic growth, to provide key public services, and to articulate calls for greater democracy. Yet, a more recent strand of literature has identified positive spin-offs from skilled emigration. These include positive effects of emigration prospects on education decisions, remittances, or diaspora externalities (Docquier and Rapoport 2012). Given the lack of clear empirical relationship between human capital and development, other studies have challenged the view that human capital losses induce economic and welfare costs in the sending countries (Clemens 2015). Consequently, the economic implications of the brain drain are still uncertain. A better understanding of the relationships between brain drain, human capital and development is necessary before getting to the bottom of the dilemmas that the brain drain poses.

In this paper, we model these relationships using a two-class, two-sector model with a formal and an informal sectors. The informal economy captures activities that are not taxed, monitored by any form of government, or included in official statistics, but that lead to economic transactions between agents. It represents about 40 percent of the recorded gross domestic product (GDP) in low-income countries, and attract more than 50 of the labor force (Schneider 2005).[1] Informal activities are mainly characterized by low-skilled intensive technologies and provide a precious source of income to those who cannot find a job in the formal economy. By draining many low-skilled workers, informality changes the skill structure of the labor force in the formal sector, and limits the size of the labor market interactions between the highly skilled and the less educated. The informal sector also drains some high-skilled workers who cannot find regular jobs in accordance with their qualifications. Acting as a buffer, informality attenuates or neutralizes the economic effects of emigration-driven changes in human capital; this may be why returns to schooling, low-skilled wages and GDP per worker poorly respond to human capital changes in poor countries (Docquier et al. 2017). Yet, the labor market interactions between the formal and informal sectors are still badly understood. Some models assume competitive labor markets and perfect mobility of workers between sectors; they fail to explain why a large income differentials exist between sectors, or why informality attracts workers from all skill groups. This paper proposes an alternative search-and-matching model *a la* Pissarides (2000), which is compatible with these facts. We use it to study how the brain drain affects the welfare of those left behind, with or without positive spin-offs from emigration. We parameterize our model on 33 sub-Saharan Africa economies. Accounting for country-specific characteristics, we produce comparative estimates of the welfare and inequality effects of the brain drain.

This paper is at the crossroad of three strands of literature. The first is the literature on *brain drain and development*. It started in the 1960s with the works of Scott and Grubel (1966) or Berry and Soligo (1969), which confront the negative and positive implications of the brain drain for the sending countries. Then, the theoretical literature of the 1970s and 1980s mainly focuses on the negative effects linked to the actual loss of human capital and to high-skilled emigration prospects. The mechanisms include labor market effects, fiscal losses, and later, the aggregate productivity responses (Bhagwati and Hamada 1974; Bhagwati and Rodriguez 1975; Rodriguez 1975; McCulloch and Yellen 1977; Miyagiwa, 1991; Haque and Kim 1995). A newer wave of studies has emerged since the mid-nineties; it discusses the ambiguous effects of the brain drain on human capital accumulation (Mountford 1997; Stark et al. 1997, 1998; Beine et al. 2001, 2008) and highlights other externalities due to the

[1] A joint study by ILO/WTO (2009) estimates that informal employment represents 55.7% of the total employment in sub-Saharan Africa. Similarly, Verick (2008) and the UN's commission for Africa (2015) report that informality accounts for 70 percent of employment in sub-Saharan Africa. Chen (2001) estimate that 93 percent of the new jobs created in sub-Saharan Africa were created in the informal economy. African Union (2008) reports that the informal employment share exceeds the share of employment in the formal economy in Kenya and Uganda. In Ghana, almost 90 percent of the labor force is employed in informal activities.

presence of a diaspora abroad (Docquier and Rapoport 2012). The main contribution of the new literature is that it is evidence-based, something which was not possible until recently due to the lack of decent comparative data on international migration by educational attainment. Our approach accounts for most of the ingredients of this literature.

The second strand of literature investigates the relationship between *informality and development*. Informality can generate vicious circles through different channels. de Paula and Scheinkman (2010, 2011) emphasize the role of value-added taxes in transmitting informality through chain effects – the informality of a firm is correlated with the informality of firms from which it buys or sells. In Zenou (2008) and Leal Ordonez (2014), informality reduces the amount of fiscal revenues that the government can allocate to social protection; in turn, this affects the attractiveness of the formal economy through greater tax rates or smaller social benefits. Murphy et al. (1989) or Krugman (1991) model firms' choice to operate formally or informally; due to fixed costs of entry, operating formally is profitable if the demand for the goods produced is large enough (i.e., when other firms industrialize and pay higher wages). In these frameworks, the predominance of informality can be seen as a result of a coordination failure. In a dynamic framework, Docquier et al. (2017) investigate the link between informality, education decisions and long-run growth. By absorbing a large share of the low-skilled labor force, the informal sector limits the skill premium in the formal sector; in addition, it facilitates child labor. Faced with lower skill premia and easier access to child labor, parents tend to choose less schooling for their children. Informality can slow down this convergence process or it can be the source of a poverty trap. The quantitative analysis reveals that the case for the poverty trap is stronger. Our model shares many ingredients with the latter study, but formalizes labor movements between the formal and informal sectors using a search-and-matching framework.

The third strand is the literature on *unemployment and underemployment in developing countries* (Ortega 2000; Yashiv 2000; Gong and van Soest 2002; Satchi and Temple 2009). Search-and-matching models à la Pissarides (2000) are widely used to study issues related to labor markets as they are considered to be based on more realistic assumptions.[2] The standard model assumes that the labor markets are not centralized, and that there exists no single price that is accepted by large number of buyers and sellers in labor market for trading. Instead, there are periods of involuntary unemployment and job search for workers. The wage rate is not equal to the marginal product of labor; there are profits and the marginal product of labor is shared by firms and workers. The income shares of workers and firms are decided through bargaining. Firms on the other hand have to pay cost for maintaining vacancies.

In our model, skilled emigration not only affects the marginal productivity of low-skilled and high-skilled workers in the home country. It also influences the duration and profitability of a vacancy, the process of job creation in the formal sector, and the outside options of workers. Hence, wage responses are not only due to changes in the marginal product, but also to changes in outside options. Our search-and-matching model allows endogenizing the share of highly skilled employed in the informal economy as well as the large wage gap between

[2]Recent studies focusing on the labor market impact of immigration to developed countries include Chassamboulli and Palivos (2014), Battisti et al. (2014), Moreno-Galbis and Tritah (2016).

sectors. Although the informal economy is recognized for being low-skilled intensive, the trend is changing and educated workers also seek for informal jobs (Verick, 2008). In Latin America, high-skilled workers accounted for about 12 percent of informal employees in 2005 (ILO/WTO, 2002), and informal wages were 44% smaller compared to those of the formal sector (ILO, 2002). To the best of our knowledge, there are no comparable figures for sub-Saharan Africa but there are some facts suggesting the presence of high skilled workers in the informal economy. In the past decades, only 37 million jobs were created between 1990 and 2010 and 28 percent of them were created in the formal sector in sub-Saharan Africa (McKinsey 2012). African economies are expected to record over 122 million entries into the labor force between 2010-2022 while only 72 million formal jobs are expected to be created. This gap between the number of formal jobs available and new entrants into labor market suggests that high-skilled workers will have to seek work in the informal economy. According to Verick (2008) many young workers with secondary or college education end up in the informal economy due to limited opportunities in the public sector and to labor mismatches in the manufacturing and service industries. Studies by Haan (2006) and Walther (2006) also suggest the presence of high skilled workers in the informal sector of African countries.

In the first part of the study we show that under a competitive formal labor market and free mobility between sectors (as in Docquier et al. 2017), the brain drain has no impact on wage rates and inequality. The effects are totally absorbed by changes in informal employment, which acts as a perfect buffer zone at low levels of development. Nevertheless, competitive economy fails to explain the observed patterns of informality and wage differential across the two sectors. Then, in the second part of the study, we add search frictions and endogenize the wage differentials across sectors as well as involuntary informal employment using a search-and-matching model. The theoretical model yields ambiguous effects of brain drain on informality. We thus parameterize the model on 33 sub-Saharan African countries and conduct a comparative quantitative analysis. The benchmark version of the model disregards any form of technological or educational externality. In this context, high-skilled wages increase almost linearly with emigration, while the wage losses for the low skilled considerably vary across countries. In particular, they depend on the education technology and on the productivity gap between sectors. Countries with better education technology and smaller productivity gap lose more in terms of income, unemployment and inequality. The results are more pessimistic if total factor productivity increases with the average level of schooling in the home country. On the contrary, allowing productivity to increase with the diaspora abroad induces slightly smaller labor market responses. In another extension of the model, we endogenize social mobility and account for brain gain effects in line with Mountford (1997) or Beine et al. (2008). A growing empirical literature shows that incentives for human capital accumulation in developing countries are based to a significant extent on migration opportunities.[3] The income loss of the brain drain is reduced by about 20% for the low-skilled when the model is calibrated to match the elasticity of training decisions to

[3] Using data on 127 developing countries, Beine et al. (2008) estimate that a doubling of a country's emigration rate of highly-skilled workers is associated with a 5% increase in the stock of human capital possessed by its nationals. Studies by Chand and Clemens (2008), Gibson and McKenzie (2011), Batista et al. (2012), Shrestha (2017) or Theoharides (2017) provide micro-level evidence of a positive impact of response net effect of skilled emigration on human capital.

skilled migration prospects. Nevertheless, our qualitative findings remain robust.

The remainder of the paper is organized as follows. Section 3.2 presents the model with exogenous total factor productivity levels and education decisions, discusses its parameterization, and quantifies the cost of the brain drain. Section 3.3 discusses extensions with endogenous total factor productivity levels and human capital accumulation. Finally, Section 3.4 concludes.

3.2 Benchmark model

We consider a developing economy with two types of infinitely-lived individuals (the highly skilled and the low-skilled, denoted by $S = (H, L)$) and with two production sectors (the formal and the informal, denoted by F and I). For simplicity, we assume that firms in the two sectors produce the same final good. Our model disregards fiscal aspects and sees informality as a subsistence sector, a relevant assumption for low-income countries. Individuals are mobile across sectors and heterogeneously mobile across countries; low-skilled workers cannot emigrate while an exogenous fraction p of the high-skilled population emigrate at each moment in time. We first describe the population dynamics and the benchmark technological assumptions in Section 3.2.1. Then, we investigate the welfare implications of skilled emigration under the competitive labor market in Section 3.2.2. We then revisit the brain drain effects using a search-and-matching model in Section 3.2.3. We focus on the steady state of the economy.

3.2.1 Population and technology

We consider an exponential population growth framework in which each group S of individual exhibits an instantaneous natural growth rate equal to g_S (reflecting exogenous fertility decisions and mortality rates). In addition, at each moment in time, an exogenous fraction ρ of the low-skilled population becomes high-skilled, while an exogenous fraction p of high-skilled individuals emigrates to a rich country (as in Mountford 1997, Start et al. 1997, 1998; Beine et al. 2001, 2008). An extension of the model with endogenous social mobility will be considered in Section 3.3. The dynamics of population is governed by:

$$\begin{aligned}
\dot{L} &= L(g_L - \rho), \\
\dot{H} &= H(g_H - p) + L\rho, \\
\dot{M} &= Hp.
\end{aligned}$$

where $\dot{X} = dX/dt$, L and H stands for the low-skilled and high-skilled populations, and M represents the stock of emigrants.

A balanced growth path for the population is reached when the size of the three groups of individual grows at the same rate g:

$$g \equiv \frac{\dot{L}}{L} = \frac{\dot{H}}{H} = \frac{\dot{M}}{M}.$$

Denoting the economy-wide skill ratio by $Z \equiv H/L$, and the proportion of high-skilled expatriates by $P \equiv M/H$, the balanced growth path condition can be rewritten as:

$$g \equiv g_L - \rho = g_H - p + \frac{\rho}{Z} = \frac{p}{P}.$$

In the benchmark version of the model, we assume that g_L, g_H, p and ρ are exogenous, and we write $g_H = ng_L$ (where $n < 1$ captures the population growth differential between high-skilled and low-skilled individuals). Hence, the long-run rate of the population growth, $g = g_L - \rho$, is exogenous. On the balanced growth path, Z and P are constant. Their steady state levels are given by:

$$Z = \frac{\rho}{g_L(1-n) - \rho + p}, \tag{3.1}$$

$$P = \frac{p}{g}. \tag{3.2}$$

The economy-wide skill ratio increases with ρ and n, and decreases with g and p. In particular, the no-migration (i.e., $p = 0$) level of the skill ratio can be defined as $Z_0 = (g_L(1-n) - \rho)^{-1} \rho$. The proportion of high-skilled expatriates increases with p and decreases with g. We impose $p < g$. If g is small, a small instantaneous rate of emigration p can give rise to a large proportion of expatriates in the long-run. In the no-migration economy, P_0 is nil.

Non-migrant workers can be employed in two sectors, the formal economy and the informal economy, where a homogeneous final good is produced. The market for the final good is perfectly competitive and the price of the final good is used as the *numéraire*. The share of type-S workers employed in the informal economy is denoted by i_S. These shares are endogenous, as explained in the next sections. Hence, the (endogenous) skill ratios in the informal and formal economies are given by:

$$\begin{aligned} Z_I &= \frac{i_H}{i_L} Z \\ Z_F &= \frac{1-i_H}{1-i_L} Z \end{aligned} \tag{3.3}$$

We now characterize the technological environment. In line with Murphy et al. (1989, 1991), Brezis et al. (1993), Mookherjee and Ray (2010) or Docquier et al. (2017), we model the informal economy as a traditional or subsistence sector characterized by constant returns. Alternative technological assumptions will be used in the robustness analysis. In the benchmark model, the quantity of final good Y_I is produced using a linear technology:

$$Y_I = A_I(L_I + H_I), \tag{3.4}$$

where A_I measures the level of total factor productivity (TFP), $L_I = i_L L$ is the number of low-skilled employees, and $H_I = i_H H$ is the number of high-skilled employees. Labor productivity in the informal sector is independent of education. The marginal productivity of each worker is equal to A_I. The labor market in the informal economy is competitive.

The formal economy corresponds to the modern sector that fully exploits the complementarities between workers. Following Acemoglu (2001), we assume that the final good Y_F is produced using a CES combination of intermediate inputs, Y_L and Y_H, which are produced by low-skilled and high-skilled workers, respectively:

$$Y_F = A_F \left[\alpha Y_L^{\frac{\sigma-1}{\sigma}} + (1-\alpha) Y_H^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}},$$

where A_F is the TFP level in sector F, α is a parameter governing the preference for the two inputs and their income shares, σ is the elasticity of substitution between the two intermediate goods. Given the assumption of perfect competition on the market for final goods, the price of each intermediate good is equal to its marginal product, $y_S \equiv \partial Y_F / \partial Y_S$. Inputs are produced using a linear technology and equal the number of workers employed in the sector, $Y_L = (1 - i_L)L$ and $Y_H = (1 - i_H)H$. Hence, the marginal products of each input can be written as:

$$y_L = A_F \alpha \left[\alpha + (1-\alpha) Z_F^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1}{\sigma-1}}, \tag{3.5}$$

$$y_H = A_F (1-\alpha) Z_F^{\frac{-1}{\sigma}} \left[\alpha + (1-\alpha) Z_F^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1}{\sigma-1}}. \tag{3.6}$$

Without loss of generality, we define the relative TFP in informality as $\psi \equiv A_I / A_F$. Such a model without physical capital features a globalized economy with a common international interest rate. This hypothesis is in line with Kennan (2013) or Klein and Ventura (2009) who assume that capital "chases" labor.

3.2.2 Competitive labor market: informality as a buffer zone

We first derive the optimal allocation of the labor force and the welfare implications of emigration under a competitive labor market in the formal sector. Perfect competition implies that the wage rates are equal to the marginal products in all sectors and for all categories of workers: $\omega_S = y_S$ in the formal sector, and $\omega_I = \psi A_F$ in informality. We first characterize the condition under which the informal sector exists and describe the optimal allocation of the workforce. Then, we study the macroeconomic and welfare implications of skilled emigration under the informality regime.

The model with competitive labor market generates two possible regimes. The first one, the *informality regime*, is obtained when output and employment are positive in the informal economy; the second one, the *formal regime*, is obtained when all workers are employed by formal firms. The condition under which the informality regime emerges requires full employment in the formal economy to be suboptimal for at least one category of worker. In particular, given (3.4) and (3.5), full employment in formality is suboptimal for low-skilled workers if the economy-wide skill ratio, Z, is smaller than a critical level:

$$A_F\alpha\left[\alpha+(1-\alpha)Z^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1}{\sigma-1}}<\psi A_F$$

$$\iff Z<(1-\alpha)^{\frac{-\sigma}{\sigma-1}}\left[\left(\frac{\psi}{\alpha}\right)^{\sigma-1}-\alpha\right]^{\frac{\sigma}{\sigma-1}}\equiv\overline{Z}_F(\psi,\alpha), \tag{3.7}$$

where the critical level of the skill ratio, $\overline{Z}_F(\psi,\alpha)$, is an increasing function of ψ. For example, if $\sigma=2$, $\overline{Z}_F\equiv\left(\frac{\psi-\alpha^2}{\alpha(1-\alpha)}\right)^2$, which is positive if $\psi>\alpha^2$. A change in ψ induces convex effects on $\overline{Z}_F$.

When condition (3.7) holds, a fraction of the low-skilled labor force finds it optimal to work in the informal sector. If $\psi=0$, this condition never holds as $\overline{Z}_F(0,\alpha)$ is negative. However, when ψ is large enough, low levels of human capital translate into positive informality employment. The movement stops when wages are equalized across sectors, i.e. when $Z_F=\overline{Z}_F(\psi,\alpha)$. At this level of the skill ratio, the wage rate of the highly skilled exceeds the low-skilled wage if

$$\overline{Z}_F(\psi,\alpha)<\left(\frac{1-\alpha}{\alpha}\right)^{\sigma}. \tag{3.8}$$

If condition (3.8) holds, high-skilled workers are better paid in the formal economy. They receive a salary $\omega_H=\Theta\omega_I$ with $\Theta=\frac{1-\alpha}{\alpha}\overline{Z}_F^{\frac{-1}{\sigma}}>1$. This implies $i_H=0$. As for the low-skilled, the equilibrium share of informal employment is such that $Z_F=\overline{Z}_F$: using (3.3), this implies $i_L=\frac{\overline{Z}_F-Z}{\overline{Z}_F}>0$, which decreases with Z (i.e., increases with p given Eq. (3.1)). Let us denote the average instantaneous income of type-S workers as:

$$\overline{w}_S\equiv(1-i_S)\omega_S+i_S\omega_I, \tag{3.9}$$

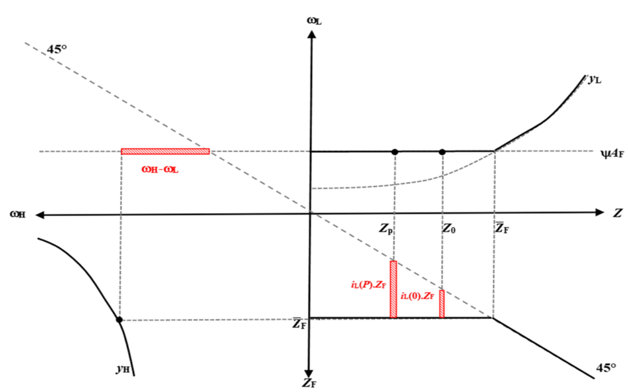
while $\overline{w}$ (without skill subscript) represent the average income of non-migrants (a weighted sum of $\overline{w}_L$ and $\overline{w}_H$).

We thus obtain the following result:

Proposition 1 *Under a competitive labor market and under the conditions $Z<Z_0<\overline{Z}_F(\psi,\alpha)<\left(\frac{1-\alpha}{\alpha}\right)^{\sigma}$, the informality regime arises for any level of p. The skill ratio in the formal economy is constant. The skill-specific wage rates and the average instantaneous income levels are independent of changes in the emigration rates ($\frac{\partial\overline{w}_S}{\partial p}=\frac{\partial\omega_S}{\partial p}=0$). The brain drain has no effect on inequality between skill groups. It increases the informal employment share of the low-skilled ($\frac{\partial i_L}{\partial p}>0$), but induces no income loss.*

The condition $Z_0 < \overline{Z}_F(\psi, \alpha)$ says a complete repatriation of high-skilled emigrants does not induce a regime switch from informality to formality; given (3.1), this is the case if ρ is sufficiently small. Figure 3.1 illustrates the mechanics of the model with a competitive labor market in the formal sector. The top-right panel shows compares the marginal productivity of low-skilled workers in both sectors. At the critical level $\overline{Z}_F$, the wage rates are equal. If $Z_0 < \overline{Z}_F$, the wage rate of low-skilled workers equals ψA_F and the informality regime arises. The bottom-right panel shows the equilibrium level of human capital in the formal economy, Z_F. If $Z_0 < \overline{Z}_F$, we have $Z_F < \overline{Z}_F$ and the informal employment rate is proportional to the difference $\overline{Z}_F - Z_0$ (the red area). By reducing human capital from Z_0 to Z_p, the brain drain increases the size of the informal economy but has no effect on the low-skilled wage rate. The bottom-left panel gives the marginal product of the highly skilled as a decreasing function of Z_F. Under the informality regime, the wage rate of the highly skilled is constant. Finally, the top-left panel represents the wage gap between high-skilled workers and the less educated.

Figure 3.1: Welfare effect of the brain drain (competitive labor market)



Proposition 1 does not imply that the brain drain has no impact on macroeconomic performance. Let us define the average informality rate (share of informal employment in total employment) by i, the recorded (formal) level of income per capita by Y^r, the national (informal + formal) level of income per capita by Y^n, and the average income per worker in the formal economy by Y^w.

The steady state levels of these variables are given by:

$$
\begin{aligned}
i &\equiv \frac{i_L L + i_H H}{L+H} = \frac{\overline{Z}_F - Z}{(1+Z)\overline{Z}_F}, \\
Y^r &\equiv \frac{(1-i_L)L\omega_L + (1-i_H)H\omega_L}{L+H} = \frac{Z}{1+Z}\left(\Theta + \frac{1}{\overline{Z}_F}\right)A_I, \\
Y^n &\equiv \frac{(1-i_L)L\omega_L + i_L L\omega_I + (1-i_H)H\omega_L}{L+H} = \frac{1+\Theta Z}{1+Z}A_I, \\
Y^w &\equiv \frac{(1-i_L)L\omega_L + (1-i_H)H\omega_L}{(1-i_L)L + (1-i_H)H} = \frac{1+\Theta\overline{Z}_F}{1+\overline{Z}_F}A_I.
\end{aligned}
$$

By reducing Z, the brain drain increases the average share of informal employment $\left(\frac{di}{dp} > 0\right)$, decreases recorded and national income per capita $\left(\frac{dY^r}{dp}, \frac{dY^n}{dp} < 0\right)$, but has no effect on the level of income per worker in the formal economy, on skill-specific wages and on income inequality $\left(\frac{dY^w}{dp}, \frac{d\omega_S}{dp}, \frac{d\Theta}{dp} = 0\right)$. This is because the migration-induced changes in the economy-wide skill ratio have no effect on $\overline{Z}_F$, the skill ratio of the formal sector. Similar predictions are obtained if emigration prospects induces limited changes in human capital, or if the brain drain gives rise to technological externalities that jointly affect the two productive sectors (leaving ψ unchanged).

Such a competitive economy is incompatible with some observed patterns of informality. First, it implies that low-skilled workers receive identical earnings in both sectors; the empirical literature has shown that significant wage disparities exist between the two sectors and for workers with similar skills (ILO 2002). Second, it implies that informal firms only employ low-skilled workers; although the average skill level is smaller in the informal sector, the empirical literature evidences the presence of high-skilled workers and entrepreneurs (Haan 2006; Walther 2006; Verick 2008). Third, the model predicts that a rising productivity gap between the two sectors (i.e., fall in ψ) induces large movements of workers between sectors; the empirical literature has shown that convergence in manufacturing productivity did not translate into large labor movements and convergence in recorded income per capita (e.g., Rodrik 2013). For these reasons, the next section revisits the welfare implications of the brain drain in a model with labor market frictions.

3.2.3 Labor market with search and matching

We now consider an alternative search-and-matching model that is compatible with (and endogenizes) income disparities between sectors for each skill group. All workers have the option to search for a better-paid job in formal sector. If the individual does not get a job in the formal sector, she works in informality. Hence, the informal economy consists of a subsistence sector that overcomes the lack of a sound, public unemployment insurance scheme. As shown in Gerxhani (2004) and World Bank (2014, p.23), one third of developing economies do not have any social protection policy or strategy, and the number of such countries is growing very recently (Haan 2006; Walther 2006; McKinsey 2012). In the absence of social protection, informality is widely tolerated by the government because it provides people with an alternative to live (see Vodopivec 2013; Robalino and Weber 2013; Margolis et al. 2012; Charlot et al. 2014, among others) and/or a minimum wage (see Basu, Chau and Kanbur 2015; Basu, Chau and Siddique 2012, among others). In our search-and-matching model, workers who cannot be employed by formal firms are absorbed by the informal sector. Informally employed workers are treated as equivalent to unemployed workers with unemployment benefit equal to wage ω_I. In equilibrium, we always have workers searching for jobs in formal sector, wages are greater in formality, and each informal employee has an incentive to move from informality to the formal economy.

We assume all informal employees search for a formal job and are matched with vacancies through a matching function $F(I_S, V_S)$ at each moment in time. The matching function exhibits constant returns to scale; I_s is the total number of type-S employees in the informal sector (i.e. $I_L = i_L L$, and $I_H = i_H H$), and V_S is the total number of vacancies available for type-S workers. Practically, we consider a standard Cobb-Douglas function with identical elasticities (both are equal to 0.5, in line with the existing literature):

$$F(I_S, V_S) = \mu_S \sqrt{I_S V_S} \tag{3.10}$$

where μ_S is a scale factor.

The job finding rate for workers in each period is given by

$$\lambda(\theta_S) = \frac{F(I_S, V_S)}{I_S} = \mu_S \sqrt{\theta_S},$$

where θ_S is the market tightness and is equal to $\frac{V_S}{I_S}$. The vacancy filling rate $q(\theta_S)$ is given by:

$$q(\theta_S) \equiv \frac{F(I_S, V_S)}{V_S} = \mu_S \sqrt{\frac{1}{\theta_S}} = \frac{\lambda(\theta_S)}{\theta_S},$$

such that $\frac{\partial q(\theta_S)}{\partial \theta_S} < 0$ and $\frac{\partial \lambda(\theta_S)}{\theta_S} > 0$. Firms pay a cost k_S for hiring a type-S worker. The cost is skill specific and includes among others, advertising costs, interview arrangements cost, initial training, time and resources invested by the firms to find a worker as well as the forgone output while maintaining the vacancy. For simplicity, we assume job search cost for workers and costs for creating a vacancy to be nil. We also disregard tax rates or severance payments both for simplicity and because of the lack of data.*Search-and-matching equilibrium for low-skilled workers.* – Let $\Omega_{F,S}$ and $\Omega_{I,S}$ represent the lifetime value of formal employment and informal employment for type-S individuals, respectively. For low-skilled workers, these values are defined as:

$$\begin{aligned} r\Omega_{F,L} &= \omega_L - \delta_L(\Omega_{F,L} - \Omega_{I,L}) + \rho(\Omega_{I,H} - \Omega_{F,L}), \\ r\Omega_{I,L} &= \omega_I + \lambda(\theta_L)(\Omega_{F,L} - \Omega_{I,L}) + \rho(\Omega_{I,H} - \Omega_{I,L}), \end{aligned}$$

where δ_L is the exogenous job destruction rate for low-skilled workers (at this rate the employed low skilled workers lose their jobs and go back into the pool of informal employees); ω_L is the wage rate paid by formal firms, and ω_I is the outside option in informality; at the rate ρ, the low-skilled become highly skilled, lose the low skilled job and enter into the pool of highly skilled informally employed workers (implying a loss of $\Omega_{F,L}$, and a gain of $\Omega_{I,H}$). Similarly, an informal employee may also become high skilled with an exogenous probability ρ. In the latter case, the agent loses $\Omega_{I,L}$ and gains $\Omega_{I,H}$.

It follows that:

$$\Omega_{F,L} - \Omega_{I,L} = \frac{\omega_L - \omega_I}{r + \delta + \lambda(\theta_L) + \rho}.$$

In equilibrium $\Omega_{F,L} > \Omega_{I,L}$. Hence, workers in informal sector always find it advantageous to search for a formal job and to accept a job offer from a formal firm.

As far as firms are concerned, let $\Phi_{V,L}$ denote the present value of a vacancy, and $\Phi_{F,L}$ be the present value of filled job for a low-skilled workers. These values are given by:

$$\begin{aligned} r\Phi_{F,L} &= y_L - \omega_L - (\delta_L + \rho)(\Phi_{F,L} - \Phi_{V,L}), \\ r\Phi_{V,L} &= -k_L + q(\theta_L)(\Phi_{F,L} - \Phi_{V,L}). \end{aligned}$$

where y_L is the marginal product of low-skilled workers, δ is the job destruction rate, and ρ is the rate at which low-skilled become highly skilled and find a job in the high-skilled sector (consequently, jobs in the low-skilled sector become vacant at the rate $\delta + \rho$).

On the balanced growth path, free entry implies that $\Phi_{V,L} = 0$ or, equivalently:

$$\begin{aligned} \Phi_{F,L} &= \frac{y_L - \omega_L}{r + \delta_L + \rho}, \\ \Phi_{F,L} &= \frac{k_L}{q(\theta_L)}. \end{aligned}$$

Hence, the job creation condition can be written as:

$$\frac{y_L - \omega_L}{r + \delta_L + \rho} = \frac{k_L}{q(\theta_L)}, \tag{3.11}$$

which determines the equilibrium level of market tightness (θ_L). This condition states that in equilibrium, the marginal benefit from a filled vacancy is equal to the marginal cost of opening a vacancy.

The wage rate is determined through Nash bargaining:

$$(1 - \beta_L)(\Omega_{F,L} - \Omega_{I,L}) = \beta_L(\Phi_{F,L} - \Phi_{V,L}),$$

where β_L is the bargaining power of low-skilled workers. Solving for the low-skilled wage gives:

$$\omega_L = \frac{\omega_I(1 - \beta_L)(r + \delta_L + \rho) + \beta_L(\delta_L + r + \lambda(\theta_L) + \rho)y_L}{r + \delta_L + \beta_L\lambda(\theta_L) + \rho}. \tag{3.12}$$

It is simply a weighted average of the wage of the informal sector and the marginal product in the formal sector.

As for the share of informal employment, its dynamics is governed by

$$\begin{aligned} &\dot{I}_L = (L - I_L)\delta_L - \lambda(\theta_L)I_L + gL \\ \Longleftrightarrow\ &\frac{\dot{I}_L}{I_L} = (\frac{L}{I_L} - 1)\delta_L - \lambda(\theta_L) + g\frac{L}{I_L}. \end{aligned}$$

On the balanced growth path, $\frac{\dot{I}_L}{I_L} = \frac{\dot{L}}{L} = g$. As $i_L \equiv \frac{I_L}{L}$, the steady state condition implies that:

$$i_L = \frac{\delta_L + g}{\delta_L + g + \lambda(\theta_L)}. \tag{3.13}$$

Search-and-matching equilibrium for high-skilled workers. – We proceed the same way for high-skilled workers, accounting for the fact that they emigrate abroad with a probability p. Let $\Omega_{F,H}$, $\Omega_{I,H}$ and Ω^* represent the lifetime value of formal employment, informal employment, and employment abroad, respectively. We have:

$$\begin{aligned} r\Omega_{F,H} &= \omega_H - \delta_H(\Omega_{F,H} - \Omega_{I,H}) + p(\Omega^* - \Omega_{F,H}), \\ r\Omega_{I,H} &= \omega_I + \lambda(\theta_H)(\Omega_{F,H} - \Omega_{I,H}) + p(\Omega^* - \Omega_{I,H}). \end{aligned}$$

At the rate p, high-skilled workers leave their jobs from any of the two sectors and go abroad to work. We assume the home country to be small; hence, Ω^* is unaffected by the labor market conditions in the home country. The wage of high skilled workers is denoted by ω_H. Since a worker can find a job abroad during employment in the informal sector or during her job in the formal sector with the same probability, p appears both in her employment and informal employment asset value functions.

As far as firms are concerned, the present values of a vacancy ($\Phi_{V,H}$) and of a filled job ($\Phi_{F,H}$) are given by:

$$\begin{aligned} r\Phi_{F,H} &= y_H - \omega_H - (\delta_H + p)(\Phi_{F,H} - \Phi_{V,H}) \\ r\Phi_{V,H} &= -k_H + q(\theta_H)(\Phi_{F,H} - \Phi_{V,H}) \end{aligned}$$

where y_H is the marginal product of the skill-intensive intermediate input. The vacancy is filled at a rate $q(\theta_H)$.

On the balanced growth path, the free entry condition implies that $\Phi_{V,H} = 0$, or equivalently:

$$\begin{aligned} \Phi_{F,H} &= \frac{y_H - \omega_H}{r + p + \delta_H}, \\ \Phi_{F,H} &= \frac{k_H}{q(\theta_H)}, \end{aligned}$$

so that the job creation condition writes as:

$$\frac{y_H - w_H}{r + p + \delta_H} = \frac{k_H}{q(\theta_H)}. \tag{3.14}$$

The wage rate is determined through Nash bargaining:

$$(1 - \beta_H)(\Omega_{F,H} - \Omega_{I,H}) = \beta_H(\Phi_{F,H} - \Phi_{V,H}),$$

where β_H is the bargaining power of high-skilled workers.

Solving for the high-skilled wage gives:

$$\omega_H = \frac{\omega_I(1-\beta_H)[r+p+\delta_H] + \beta_H[\delta_H + r + p + \lambda(\theta_H)]y_H}{r+\delta_H+p+\beta_H\lambda(\theta_H)}, \tag{3.15}$$

while the equilibrium share of informal employment requires $\frac{\dot{I}_H}{I_H} = \frac{\dot{H}}{H} = g$. This implies:

$$i_H = \frac{\delta_H + g}{\delta_H + g + \lambda(\theta_H) + p}. \tag{3.16}$$

Definition of the general equilibrium. – We can define the steady state, general equilibrium of our search-and-matching model by combining the technological characteristics of the economy, the conditions governing population dynamics, and the labor market equilibrium conditions for both types of workers. This gives:

Definition *For a set of country-specific parameters* $\{g, n, \rho, p, \sigma, \alpha, r, \beta, A_F, A_I\}$ *and a set of skill-specific parameters* $\{\delta_S, k_S, \mu_S\}_{S=(H,L)}$*, the steady state equilibrium of the search-and-matching model is a set* $\{Z, Z_F, y_L, y_H, \theta_L, \theta_H, i_L, i_H, \omega_L, \omega_H\}$ *of ten endogenous variables satisfying the following ten conditions: (i) the optimal composition and allocation of the workforce is given by (3.1) and (3.3), (ii) the profit-maximizing levels of marginal productivity are given by (3.5) and (3.6), (iii) and the search-an-matching equilibrium conditions are (3.11), (3.12), (3.13), (3.14), (3.15) and (3.16).*

The other variables of the model can either be computed as a transformation of the parameters (e.g., $\omega_I = A_I$, $\psi = A_I/A_F$, $P = p/g$) or can be computed as by-products of the endogenous variables (e.g., $\overline{w}_S$ combines ω_S and i_S using Eq. (3.9)).

Effect of the brain drain. – How does the brain drain affect the steady state of the economy and the welfare of non-migrants? First, in Eq. (3.1), skilled emigration changes the composition of the labor force. For given informality rates, this induces first-order effects on the composition of the labor force in the formal economy (see Eq. (3.3)), and subsequent changes in the marginal products of intermediate goods, governed by Eqs. (3.5)-(3.6). The size of these first-order effects on the marginal products depends on the elasticity of substitution between intermediate goods: changes in y_S are small if σ is large, and conversely. Second, changes in the marginal products translate into changes in market tightness and wage rates; these changes are obtained by solving Eqs. (3.11)-(3.12) for the low-skilled, and by solving Eqs. (3.14)-(3.15) for the highly skilled. Third, emigration has a direct negative effect on the expected values of a filled vacancy and of accepting a formal job. Finally, changes in market tightness affects informality rates, as shown in Eqs. (3.13) and (3.16), with second-order effects on Z_F and on the marginal products of intermediate goods.

The model is strongly non linear and a closed-form solution cannot be identified. However, to shed light on the mechanics of the model, let us dissect the labor market responses. For the low-skilled population, the equilibrium value of $y_L - w_L$ can be derived from (3.12) and from (3.11); equalizing them gives:[4]

$$\frac{(1-\beta_L)(y_L-\omega_L)}{(r+\delta_L+\rho)+\beta_L\lambda_L(\theta_L)}=\frac{k_L\lambda_L(\theta_L)}{\mu_L^2}.$$

For the highly skilled, the equilibrium value of $y_H - w_H$ can be derived from (3.15) and from (3.14); equalizing them gives:

$$\frac{(1-\beta_H)(y_H-\omega_I)}{(r+\delta_H+p)+\beta_H\lambda_H(\theta_H)}=\frac{k_H\lambda_H(\theta_s)}{\mu_H^2}.$$

where λ_H is at the equilibrium level of θ_H.

We have:

Proposition 2 *Under a search-and-matching labor market, the informality regime arises for any level of p. The effect of the brain drain on inequality between skill groups depends on the substitutability between high-skilled and low-skilled intermediate goods in the formal economy. If the elasticity of substitution is small, the brain drain increases inequality between skill groups (making low-skilled workers worse off, and high-skilled, non-migrants better off). If the elasticity of substitution is large, it decreases inequality (making high-skilled, non-migrants worse off).*

We demonstrate this result, first focusing on the low-skilled. When p increases, the first-order effect is channelled by the marginal product of low-skilled workers. Due to a decline in the number of high-skilled workers, y_L changes. The elasticity of substitution between intermediate goods (σ) governs the changes in the marginal product. If σ equals infinity, y_L does not vary and there is no effect on low-skilled workers. For finite levels of σ, y_L decreases. The wage of the low-skilled decreases. A fall in y_L reduces the profits from low-skilled vacancies and the level of θ_L. Hence, the value of outside option decreases as well, which further deteriorates w_L. Due to a rise in y_H after the brain drain, the profits from high-skilled vacancies increases, which leads to more job postings for educated workers. This increases θ_H and the number of high-skilled workers in the formal sector. This attenuates the initial effect of y_L.

We now turn our attention to the highly skilled. If σ is small, the brain drain increases y_H. An increase in the marginal product of the skill-intensive input increases profits from high skilled vacancy and θ_H. At the same time a rise in p makes it difficult to hire high-skilled workers. The profits from high-skilled vacancies decrease. Hence, w_H increases with p due to higher y_H and to improved outside options. The variation in θ_H is uncertain. On the contrary, if σ equals infinity, y_H does not vary and the effect on w_H and θ_H comes only from changes in outside options (i.e., the change in the number of workers searching for jobs). Since y_H is constant, a rise in p increases w_H due to improved outside options for high skilled workers. It also makes it difficult to hire high skilled workers, which reduces θ_H. Theoretically, the effect on w_H remains ambiguous.

[4]We use $\lambda_S(\theta_s)=\mu_S\sqrt{\theta_S}$ and $\lambda_S(\theta_s)q_S(\theta_s)=\mu_S^2$ from (3.10).

Once labor market frictions are included into the model, the inequality response to the brain drain becomes ambiguous. Numerical simulations can thus be used to identify which of these two outcomes is the most plausible.

3.2.4 Quantitative analysis

Our benchmark model is parameterized to match the economic and socio-demographic characteristics of 33 sub-Saharan African economies in the year 2010, which is meant to represent the steady state. The choice of 33 countries is guided by data availability; more precisely, we select sub-Saharan African for which estimates of the informality shares in employment and value added are available. We parameterize the model to match the population structure of each country, its recorded level of income per capita, as well as its shares of informality in employment and in the value added. Once the model is calibrated, we quantify the effect of the brain drain by simulating a counterfactual search-and-matching equilibrium with $p = 0$. In this section, we describe the parameterization strategy, we discuss the simulation results, and we check their robustness to a number of identifying assumptions.

Paramaterization. – Table 3.1 summarizes the calibration outcomes (see Table B1 in the Appendix for chapter 03 for more details). The model includes six parameters that we consider as identical across countries. Using data from Kremer and Chen (1999), we compute the differential fertility in 1985-89 for 26 developing countries. The correlation between country-specific fertility differentials and the human capital of women is low (0.14). We thus consider the fertility differential as independent of the level of development. The average fertility differential g_H/g_L between high-skilled (i.e., college graduates) and low-skilled workers (i.e., the less educated) equals 0.605; it shows little variations across countries. We use the value $n = 0.605$ in all countries. As far as the elasticity of substitution between intermediate goods is concerned, we use the elasticity of substitution between high-skilled and low-skilled workers estimated by Ottaviano and Peri (2012) for a one-sector model; this gives $\sigma = 2$. For the interest rate, we use the average t-bill rate for developed countries (4% per year) and compute the monthly rate; this gives $r = 0.0033$. In line with Gong and Soest (2002) and Satchi and Temple (2009) on Mexico, the job destruction rates are set to $\delta = 0.06$ for both skill groups. The vacancy costs is assumed to be equal to 40% of the wage rate; we use $k_S = 0.4\omega_S$ in the pre-shock economy and for both skill groups; however, when brain drain shocks are simulated, we keep the absolute level of k_S (in USD) constant. As for the bargaining power of workers, the literature on developed countries uses a value around 0.5. However, Satchi and Temple (2009) recommends a value of 0.7 when the informal sector is above 30%; we use $\beta = 0.7$ in all countries. Alternative parameters values are considered in the robustness analysis.

The model also includes eight parameters that vary across countries to match some moments for the year 2010. We collect data on official GDP and on the working-age population size and growth rates (g) from the World Development Indicators (World Bank, 2016), and data on the proportion of college graduates in the labor force from Artuç et al. (2015). We combine them with data on informal employment as percentage of the labor force, and informal

Table 3.1: Common and country-specific parameters

	Description	Mean	St. dev.	Source/Moment matched
Parameters without country variation				
n	Pop. growth differential	0.605	-	Kremer and Chen (1999)
σ	Elast. subst. btw inputs	2.000	-	Ottaviano and Peri (2012)
r	Monthly interest rate	0.003	-	Batisti et al. (2015)
δ_S	Monthly job destruction	0.060	-	Gong/Soest (2002), Satchi/Temple (2009)
k_S/ω_S	Vacancy cost/Wage	0.400	-	Satchi and Temple (2009)
β	Bargaining power	0.700	-	Satchi and Temple (2009)
Parameters varying across countries				
A_F	TFP in the formal sector	2055.0	2600.0	Matches official GDP per capita
α	Firm preference for input	0.506	0.104	Matches observed wage ratio
A_I	TFP in the informal sector	139.3	195.6	Matches informal inc. per worker
p	Monthly emigration rate	7.9E-04	7.4E-04	Matches prop. of HS emigrants
ρ	Social mobility rate	4.8E-05	3.17E-05	Matches observed skill ratio
g	Monthly pop. growth rate	4.3E-04	9.4E-05	Matches pop. growth rate
μ_L	Matching scale factor, LS	0.103	0.048	Matches share of formal empl.
μ_H	Matching scale factor, HS	0.214	0.068	Matches share of formal empl.

activities as percentage of official income from Schneider (2012). The latter database does not distinguish informal workers by education level; in the benchmark simulations, we assume that the informal employment rate of college graduates is half the informal employment rate of the less educated (i.e., $i_H = 0.5 i_L$); alternative assumptions values are used in the robustness checks. This allows us to proxy the size and the skill structure of the labor force in each sector, as well as the average levels of income per worker. The TFP levels in the formal and informal sectors, A_F and A_I, match these average income levels, while α is calibrated to match the wage ratio between college graduates and less educated workers, as estimated in Hendriks (2004). The monthly emigration rates of college graduates, p, is calibrated to match the proportion of high-skilled expatriates reported in Artuç et al. (2015). The social mobility rate, ρ, matches the observed skill ratio. Finally, the scale factors of the matching function, μ_L and μ_H, are calibrated to match the formal and informal shares in employment.

Welfare effect of the brain drain.– We use the parameterized model to quantify the welfare and inequality effects of skilled emigration. To do so, we simulate the hypothetical search-and-matching equilibrium assuming a zero emigration rate for the highly skilled. On Figure 3.2, we plot the effect of the brain drain (measured as the relative difference between the observed equilibrium value and the no-migration counterfactual equilibrium value) on the vertical axis, and the observed proportion of high-skilled expatriates (P) on the horizontal axis. A positive variation on the vertical axis means that the brain drain increases the level of the variable of interest. Note that all results in Figure 3.2 are also reported in Table B2 in the Appendix.

Figure 3.2.a reports the results for the average monthly income of all non-migrants (i.e. $\overline{w}$ measured by Eq. (3.9)). The effect of the brain drain is negative in all countries and the loss increases with the intensity of migration. However, the coefficient of correlation between $\Delta\overline{w}/\overline{w}$ and P only amounts to 0.5; this suggests that the average welfare effect of the brain drain is not only determined by P, but also depends on other country characteristics. For example, the greatest income loss amounts to 13% in the Democratic Republic of Congo, which only has 15% of its college-educated natives abroad; by comparison, the average income loss equals 4% in Gambia, where P amounts to 68%. Figure 3.2.b represents the inequality response to the brain drain; inequality is proxied by the ratio of average income between high-skilled non-migrants and the low-skilled ($\overline{w}_H/\overline{w}_L$). The inequality effect of the brain drain increases linearly with P, and the correlation with P is close to unity. The largest effect is obtained in the Gambia (+73.5%), while Burkina Faso exhibits the smallest response (+3.7%).

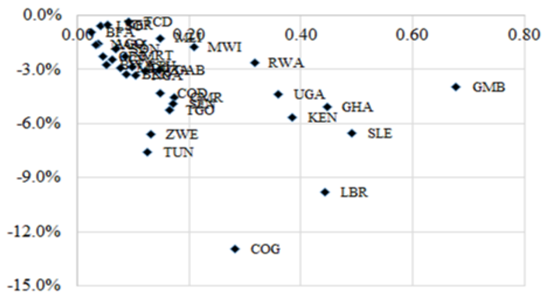
Figures 3.2.c and 3.2.d depict the effect on the average income of low-skilled and high-skilled workers (i.e., $\overline{w}_L$ and $\overline{w}_H$, respectively). As far as high-skilled workers are concerned, the effect is always positive and proportional to the size of the brain drain (correlation of 0.99 with P). The income response is large, reaching 70% in the Gambia. This is due to the fact that the proportion of high-skilled is small in sub-Saharan African countries (between 2 and 5%). Hence, these countries produce a low quantity of skill intensive, intermediate goods, and the marginal productivity of these goods is large. In other words, a small decrease in the number of highly educated workers induces large aggregate productivity changes in the formal sector. The semi-elasticity of the average income of the high-skilled to P is close to unity. On the contrary, the welfare response for the low-skilled is strongly heterogeneous across countries, and less correlated with P (correlation equal to -0.55). This is clearly in line with Figure 3.2.a. As stated above, the low-skilled population represents between 95 and 98% of the labor force in developing countries; income responses for the low-skilled are almost equal to the average income response of the whole population. This suggests that the parameters governing the search-and-matching equilibrium matter for the low-skilled.

Figures 3.2.e and 3.2.f disentangle the income responses of the low-skilled, distinguishing between the informal employment effect (on i_L) and the wage effect (on ω_L). In all cases, the brain drain increases the share of informality and reduces the wage rate. The correlation between the wage and employment responses equals 0.95. Hence, there are countries where the labor market outcomes of the low-skilled are highly responsive to the brain drain (e.g., the Democratic Republic of Congo, Liberia, Nigeria, Tunisia or Zimbabwe), and others where they are much less responsive (e.g., Rwanda, Uganda, the Gambia). Finally, Figures 3.2.g and 3.2.h disentangle the income responses of the high-skilled. The brain drain decreases the share of informality and increases the wage rate; the effects are virtually linear in P.

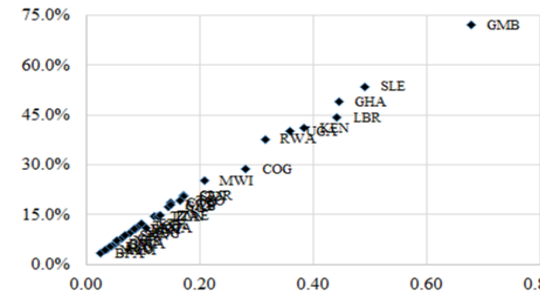
It is important to discuss the mechanism at work here a bit further. As p increases the marginal productivity of high skilled increases, making it profitable for the firms to open high-skilled vacancies. This leads to an increase in market tightness for high skilled as well as to an increase in ω_H and $1 - i_H$. This is because the marginal product of high skill-intensive goods increases and because the bargaining position of the highly skilled strengthens due to

Figure 3.2: Welfare effect of the brain drain with search and matching; (Horizontal axis: baseline; Vertical axis: Alternative identifying assumptions)

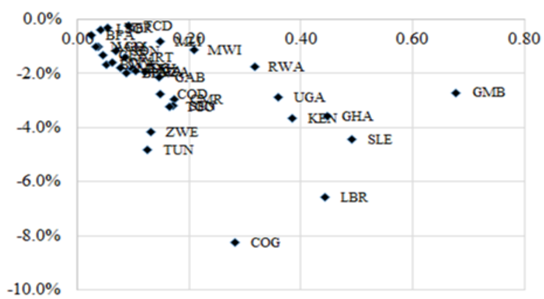
(a) 3.2a Average income effect ($\frac{\Delta\overline{w}}{\overline{w}}$)



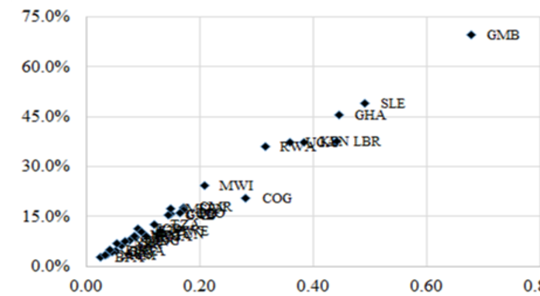
(b) 3.2b Inequality effect ($\frac{\Delta\overline{w_H}}{\overline{w_H}} - \frac{\Delta\overline{w_L}}{\overline{w_L}}$)



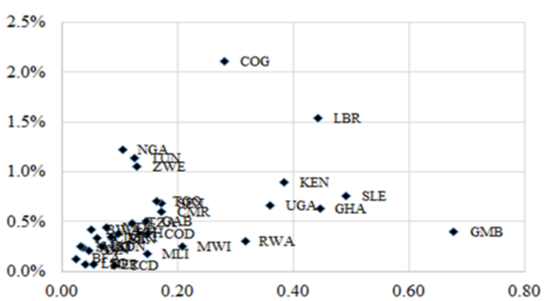
(c) 3.2c Income effect for low skilled ($\frac{\Delta\overline{w_L}}{\overline{w_L}}$)



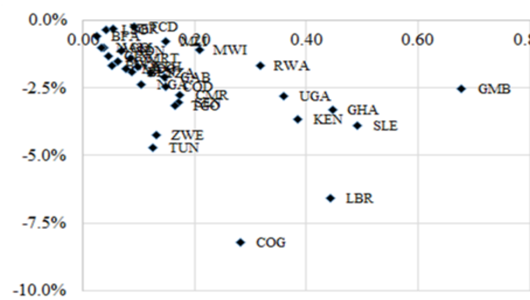
(d) 3.2d Effect for high skilled ($\frac{\Delta\overline{w_H}}{\overline{w_H}}$)



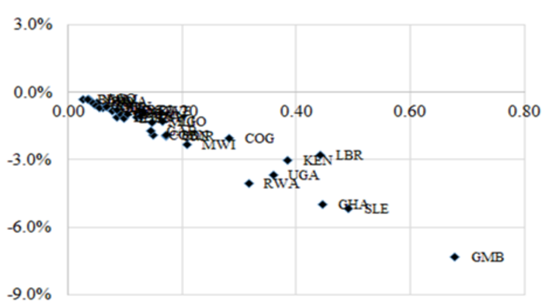
(e) 3.2d Effect on informality for low skilled (Δi_L)



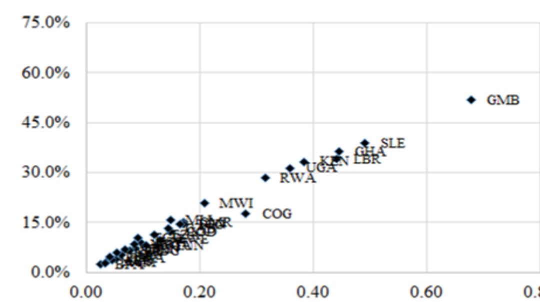
(f) 3.2e Wage effect for low skilled ($\frac{\Delta\omega_L}{\omega_L}$)



(g) 3.2f Effect on informality for high skilled (Δi_H)



(h) 3.2g Wage effect for high skilled ($\frac{\Delta\omega_H}{\omega_H}$)



improved outside options. On the contrary, the low skilled experience a decrease in ω_L and $1 - i_L$. This is because their marginal product decreases, leading to a decline in θ_L which, in turn, weakens the bargaining position of low-skilled workers by adversely affecting their outside options. Due to increase in θ_H, the number of highly skilled in the formal sector increases, and this positively affects the marginal productivity of low-skilled workers. This mitigates some of the effect of brain drain on w_L.

Robustness to parameter values. – Before explaining these cross-country differences in the labor market responses for the low-skilled, let us demonstrate that such heterogeneous responses are not driven by our calibration strategy. Most of our common parameters are calibrated in line with the existing literature, and the country-specific parameters are calibrated to match some moments. However, by using $\beta = 0.7$, we deviate from the vast majority of studies conducted for developed economies. In addition, in the absence of data on informal employment by education level, our baseline calibration arbitrarily assumes that $i_H/i_L = 0.5$ (i.e., the share of informal employment of the high-skilled is half that of the low-skilled). Finally, when simulating the no-migration counterfactual, we assume that the absolute cost of posting a vacancy remains constant. On Figure 3.3, we consider three alternative scenarios: (i) one with $\beta = 0.5$, (ii) one assuming $i_H/i_L = 0.25$ in the pre-shock economy, and (iii) one assuming $k_s = 0.4\omega_S$ in both pre-shock and counterfactual equilibria. Focusing on the employment and wage responses of the low-skilled, Figure 3.3 compares the baseline results from Figure 3.2 (on the horizontal axis) with the alternative results (on the vertical axis). All other country-specific parameters are recalibrated to match the moments, in line with the last column of Table 3.1.

Figures 3.3.b, 3.3.d and 3.3.f show that our results for the wage effects are highly robust to our three identifying assumptions (the baseline and alternative responses are remarkably close to the 45° line). Similarly, Figure 3.3.a and 3.3.c shows that our results for the employment effects are highly robust to the choice of β and i_H/i_L. Smaller employment responses are obtained when $k_s = 0.4\omega_S$ in the after-shock economy: this is because the decrease in ω_S negatively impacts the cost of posting a vacancy, therefore attenuating the employment response. However, the results are qualitatively similar.

Robustness to the technological environment. – In line with Murphy et al. (1989, 1991), Brezis et al. (1993), Mookherjee and Ray (2010) or Docquier et al. (2017), our benchmark model assumes a linear technology in the informal economy. There is, however, a big deal of uncertainty about the way to model the technology of the informal sector. Heterogeneity in informal firms' productivity has been documented in Fields (1990, 2005) and Gunther and Launov (2012), who identify the existence of an upper-tier and a lower-tier (or easy-entry) parts of the informal economy. The latter consists of employment that is free-entry, low wage, and undesirable relative to formal sector employment. The former consists of employment (either wage or self-employment) that is limited-entry and closer to formal sector employment. Still, the upper-tier sector mainly comprises small-scale, low-productivity, frequently family-based enterprises employing low-skilled workers (Maloney 2004). To assess the sensitivity of our results to the technological environment, we consider three alternative production functions for informal firms: (i) the first one is a linear production function with a constant productivity gap between high-skilled and low-skilled workers; (ii) the second one is a CES production function with an elasticity of substitution equal to 4 (σ_I); the third one is a CES function with $\sigma_I = 2$. In all cases, the parameters are re-calibrated to match the average productivity of informal firms as well as the skill premium of the formal economy.

Figure 3.4 compares the employment and wage responses of the low-skilled under the benchmark model (on the horizontal axis) and under the technological variants (on the vertical axis). Figure 3.4.a, 3.4.c and 3.4.e shows that the employment responses are highly robust to the technological environment. Figure 3.4.b, 3.4.d and 3.4.f shows that the wage effects are also highly robust. The heterogeneous responses to the brain drain are not driven by our technological specifications.

Dissecting cross-country disparities. – We now focus on the average monthly income of the low-skilled, and investigate the source of cross-country disparities in the response to the brain drain (as shown on Figure 3.2). Our model includes eight country-specific parameters that influence these responses. These parameters can be grouped into three subsets: $X^Z = \{\rho, g\}$ are parameters governing human capital accumulation, $X^M = \{\mu_L, \mu_H\}$ are parameters governing the effectiveness of the matching process, $X^T = \{A_F, \alpha, \psi\}$ are parameters reflecting technological differences across countries. The generic function governing the income response to the brain drain for the low-skilled can be expressed as:

$$\frac{\Delta \overline{w}_L}{\overline{w}_L} = R(X^Z, X^M, X^T; p)$$

To identify the role of each set of country characteristics, we simulate the country specific changes in the average monthly income of the low-skilled for all parameters subsets X jointly set at the median (X_{med}), and for each subset of parameter set at its median value one at a time. We obtain four counterfactual vectors of variations in expected income (each vector includes 33 country-specific simulation results), denoted by $R^A = R(X^Z_{med}, X^M_{med}, X^T_{med}; p)$, $R^Z = R(X^Z_{med}, X^M, X^T; p)$, $R^M = R(X^Z, X^M_{med}, X^T; p)$ and $R^T = R(X^Z, X^M, X^T_{med}; p)$. Figure 3.5 shows the results of these counterfactual experiments, which can be easily compared to the baseline results in Figure 3.2.c.

Figure 3.5.a shows that R^A is a smooth convex function of P: if all countries shared the same characteristics, the average income loss for the low skilled could be almost perfectly predicted using a quadratic function of P. The R-squared of this P-trend, quadratic regression on 33 observations equals 0.954.[5] To identify the role of country characteristics, similar regressions can be ran using R^Z, R^M or R^Tas a dependent variable. Figure 3.5.b shows that the relationship between R^Z and P becomes smoother after neutralizing cross-country differences in human capital accumulation; the R-squared of the quadratic regression on P equals 0.737. Similarly, the R-squared reaches 0.700 after neutralizing technological differences between countries (see Figure 3.4.d). On the contrary, Figure 3.5.c shows the same level of dispersion as in the baseline scenario; the R-squared of the quadratic trend equals 0.441. These results suggest that the income impact of the brain drain is not only affected by the size of the

[5]Note that the R-squared reaches 0.998 when assuming that vacancy costs remains proportional to the wage rate of the formal economy in the no-migration equilibrium. In the baseline model with country-specific characteristics (see Figure 3.2.c), conducting a similar quadratic regression generates a R-squared of 0.457 only (i.e., the quadratic approximation poorly explains cross-country disparities).

phenomenon. It also depends on the educational and productive characteristics of countries (which influence the size of the informal sector).

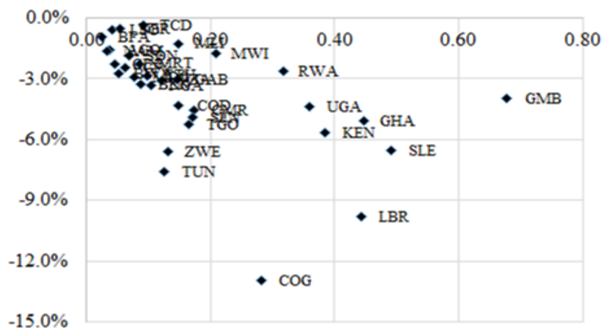
In Table B4 in the Appendix, we compute the R/R^A ratio for all countries, and we identify the difference with the baseline when each subset of parameter is set the the median. When adding the contribution of each parameter set (i.e. $R - R^Z$, $R - R^M$ and $R - R^T$), the sum exhibits a correlation of 0.863 with $R - R^A$; the difference is due to general equilibrium effects or equivalently, due to the interactions between the channels of transmission of brain drain shocks. We identify 15 countries where R/R^A is greater than 4/3 (i.e., defined as countries where the cost of the brain drain is above the trend) or smaller than 3/4 (i.e., defined as countries where the cost is below the trend). For these 15 countries, Table 3.2 identifies the main cause(s) of the deviation (i.e., the set(s) of characteristics that explain(s) the deviations from a normal response). With the exception of Zimbabwe, the contribution of the matching process is usually small. On the contrary, the contributions of educational and technological parameters mostly govern the cost of the brain drain for the low-skilled. Countries exhibiting brain drain costs above the quadratic P-trend have a better educational technology (i.e., ρ is large or g is small), and a large productivity gap between sectors (i.e., A_F is large or ψ is small). In these countries, the informal sector is less productive and emigration-driven shocks on human capital are mostly absorbed by the formal economy (as it would be the case in a one-sector model). This group of countries includes Bostwana, the Republic of Congo, Cote d'Ivoire, Guinea, Namibia and Tunisia. Countries exhibiting brain drain costs below normal exhibit poor education systems (i.e., ρ is small), and a small productivity gap between sectors (i.e., A_F is small or ψ is large). This group includes Chad, the Gambia, Lesotho, Malawi, Mali, Niger, Rwanda, Uganda and Zimbabwe). In these countries, the informal economy acts as a buffer zone, which attenuates the effect of the brain drain. The role of the productivity gap is intuitive. In countries where the productivity gap between the two sectors is small, it is less costly for low-skilled workers to leave the formal sector. Similarly, in countries with better education technology the low skilled have a higher marginal product in the formal sector and hence higher wage than in the countries with the worse education technology. So, the brain drain driven decline in θ_L in all countries leads to a bigger wage loss to low-skilled in countries with better education technologies.

Table 3.2: Brain drain effect above vs. below the P-trend

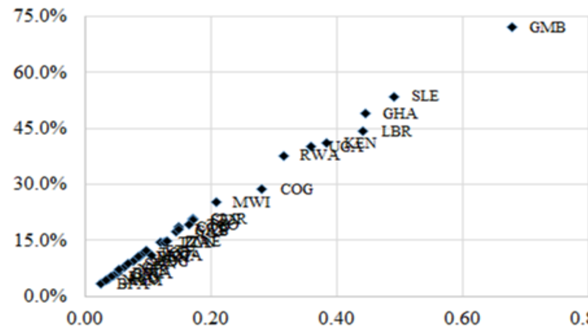
	X^Z	X^M	X^T
$\|R\| \gg \|R^A\|$	Botswana		Botswana, Guinea
Income loss	Rep. Congo	-	Rep. Congo, Namibia
above trend	Tunisia		Cote d'Ivoire, Tunisia
$\|R\| \ll \|R^A\|$	Gambia, Malawi, Mali		Tchad, Lesotho, Malawi
Income loss	Niger, Rwanda, Uganda	Zimbabwe	Mali, Rwanda, Uganda
below trend	Zimbabwe		Zimbabwe

Figure 3.3: Sensitivity of Δi_L and $\frac{\Delta\omega_L}{\omega_L}$ to identifying assumptions;(Horizontal axis: baseline; Vertical axis: Alternative identifying assumptions)

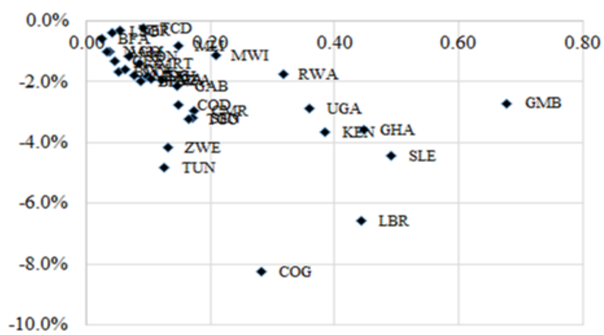
(a) 3.3a Calibration with $\beta = 0.5(\Delta i_L)$



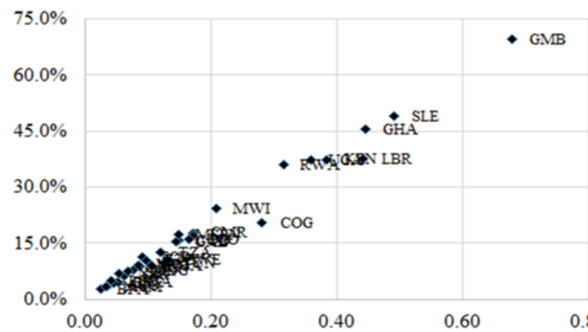
(b) 3.3b Calibration with $\beta = 0.5(\frac{\Delta\omega_L}{\omega_L})$



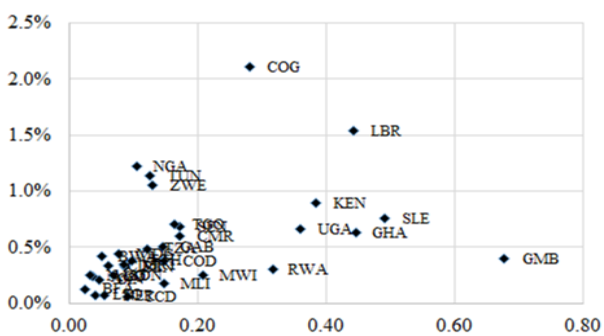
(c) 3.3c Calibration with $\frac{i_H}{i_L} = 0.25(\Delta i_L)$



(d) 3.3d Calibration with $\frac{i_H}{i_L} = 0.25(\frac{\Delta\omega_L}{\omega_L})$



(e) 3.3e Calibration with $k_s = 0.4w_s(\Delta i_L)$



(f) 3.3f Calibration with $k_s = 0.4w_s(\frac{\Delta\omega_L}{\omega_L})$

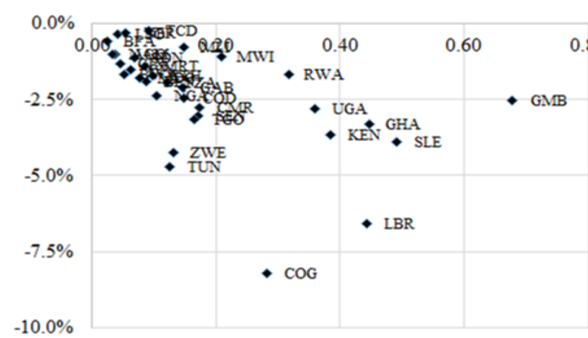
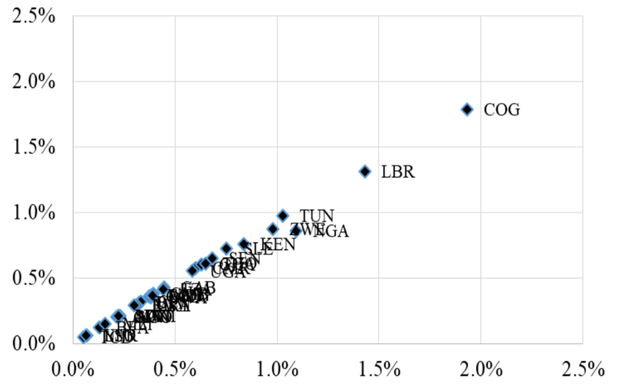
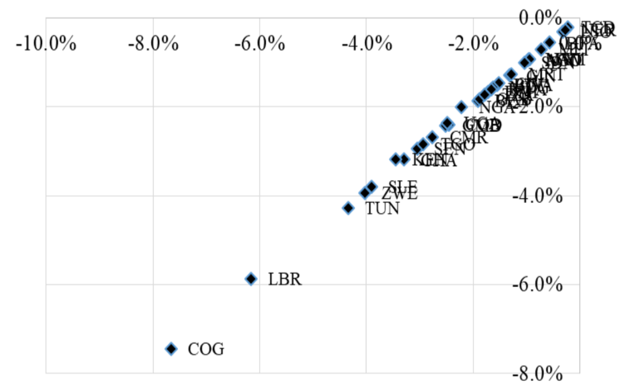


Figure 3.4: Sensitivity of Δi_L and $\frac{\Delta \omega_L}{\omega_L}$ to the technological environment

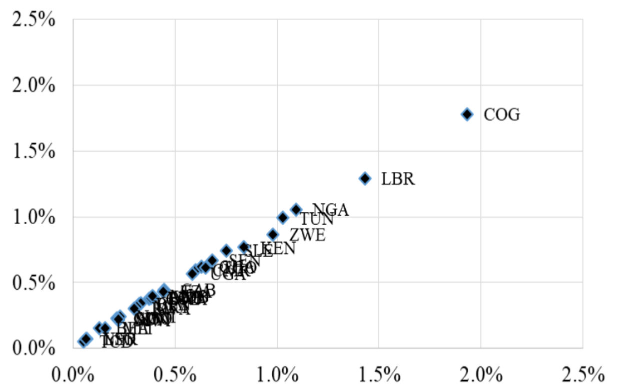
(a) 3.4a Linear techn. with skill premium Δi_L



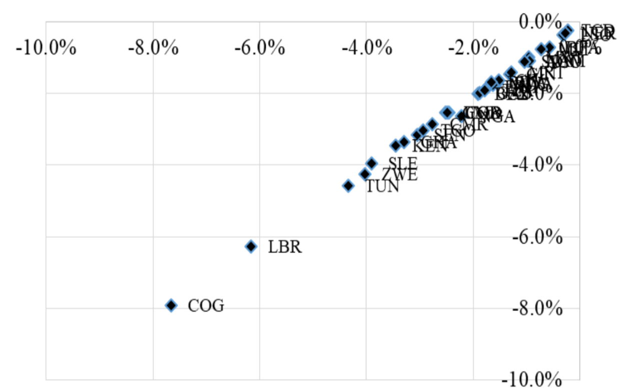
(b) 3.4b Linear techn. with skill premium $\frac{\Delta \omega_L}{\omega_L}$



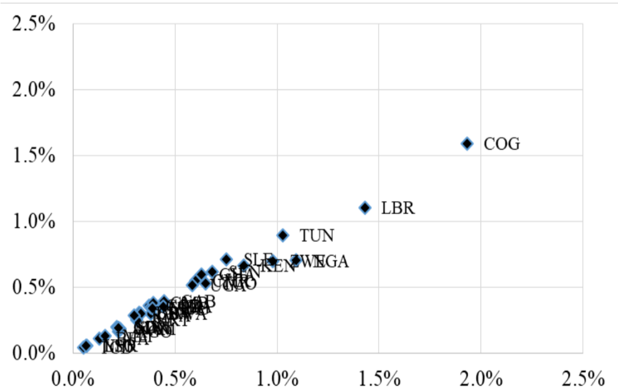
(c) 3.4c CES with $\sigma = 4(i_L)$



(d) 3.4d CES with $\sigma = 4(\frac{\Delta \omega_L}{\omega_L})$



(e) 3.4e CES with $\sigma = 2(i_L)$



(f) 3.4f CES with $\sigma = 2(\frac{\Delta \omega_L}{\omega_L})$

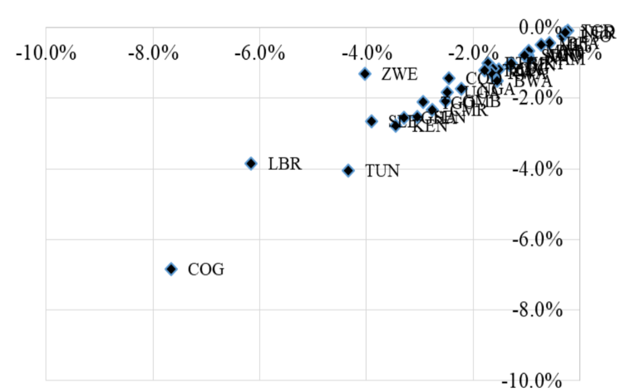
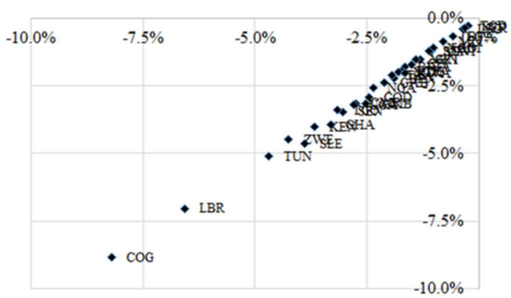
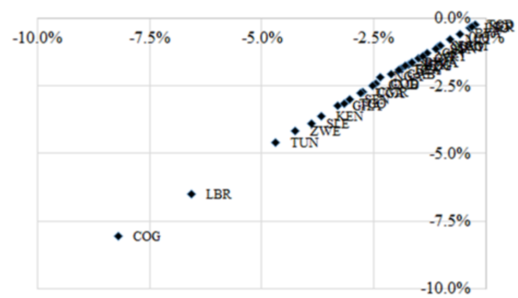


Figure 3.5: Sensitivity $\frac{\Delta \overline{w_L}}{\overline{w_L}}$ to country-specific parameters;(Horizontal axis:P; Vertical axis:$\frac{\Delta \overline{w_L}}{\overline{w_L}}$; Alternative parameters values)

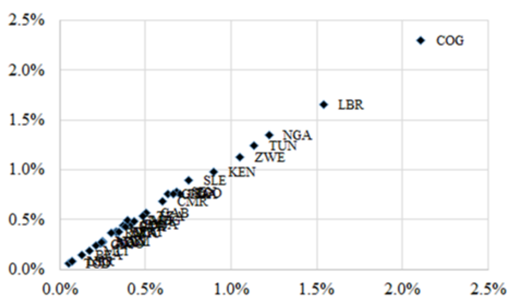
(a) 3.5a $R^A(p)$



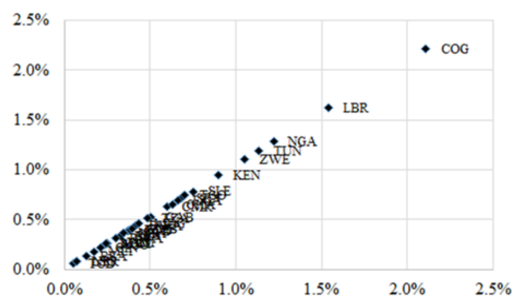
(b) 3.5b $R^Z(p)$



(c) 3.5c $R^M(p)$



(d) 3.5d $R^T(p)$



3.3 Additional mechanisms

We now investigate whether the income responses to skilled emigration are affected by technological externalities (i.e., by TFP responses to emigration) and after endogenizing training decisions. The size of technological externalities and of the emigration-driven incentives to educate has generated a certain level of debate in the literature. We use here simple specifications for the externalities and optimistic elasticity levels that can be found in the literature. We then check whether such spillover effects influence the size of the welfare responses to skilled emigration.

Extension with endogenous productivity. – We consider two types of externalities and two scenarios regarding their sector-biased structure. We first consider a standard schooling externality, assuming that TFP increases with the skill ratio in the whole economy. In the first variant, we assume that this externality is sector-biased and only affects the formal economy. We have:

$$A_F = \overline{A}_F Z^{\epsilon},$$

where $\overline{A}_F$ is a scale factor parameterized to match the observed TFP level. Following de la Croix and Docquier (2012) or Aubry et al. (2016), we consider a concave function with an elasticity ϵ equal to 0.3. This implies that A_F increases by a factor of $(Z_0/Z)^{0.3}$ in the counterfactual with $p = 0$. In the second variant, we assume that the same schooling externality operates in the informal sector as well and with the same intensity (i.e., $A_I = \overline{A}_I Z^{\epsilon}$), due to intersectoral spillover effects.

The second externality is a diaspora externality. It captures the effect of emigration on trade and FDI, and the resulting effect of trade and FDI on TFP. A first strand of literature has identified a causal impact of migration on trade and FDI, with respective elasticities of 0.1 and 0.2 (e.g. Iranzo and Peri 2009; Felbermayr et al. 2010; Parsons and Vezina 2017; Kugler and Rapoport 2007; Javorcik et al. 2011) Another strand has identified a causal effect of trade and FDI on TFP, with respective elasticities of 0.3 and 0.01 (see Anderson et al. 2017; Feyrer 2009). Combining these findings gives an elasticity of TFP to migration around 0.05. We assume that this externality is expressed as

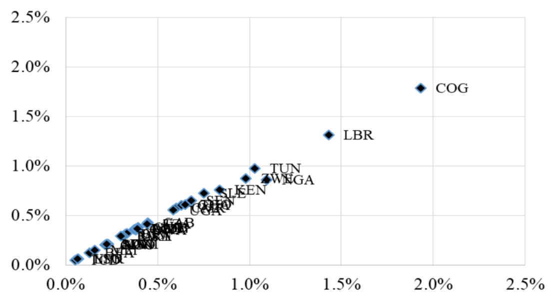
$$A_F = \overline{A}_F(1 + \kappa m),$$

where m denotes the proportion of migrants abroad (in our model, m is the product of the proportion of high-skilled by the proportion of emigrant, $m = \frac{zP}{1+z}$), κ is the incidence parameter. The choice of this analytical form ensures that the TFP level remains positive when $m = 0$. The elasticity of TFP to the proportion of emigrants is thus given by $\frac{\kappa m}{1+\kappa m}$. We calibrate κ in such a way that this elasticity is equal to 0.05 when the proportion of migrants abroad equals 1.5% (the average level observed in low-income countries); this gives $\kappa = 3.5$. This implies that A_F decreases by $3.5m$ percent in the counterfactual with $p = 0$. In the second variant, we assume that the same diaspora externality operates in the informal sector with the same intensity (i.e., $A_I = \overline{A}_I(1 + \kappa m)$).

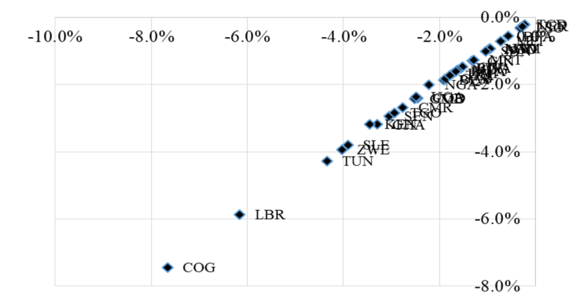
Fig. 2.6 compares the effect of the brain drain on the average monthly income of the low-skilled (left panel) and of the high-skilled (right panel) with or without technological externalities. As far as the low-skilled are concerned, the schooling externality plays a key role. On average, the loss of income increases by a factor of 4.4 when the externality operates in the formal sector only (Figure 3.6.a), and by a factor of 5.0 when it affects both sectors of the economy (Figure 3.6.c). In countries with low human capital levels, the effect is multiplied by 10 to 15. These include the Gambia, Uganda, Sierra Leone, Ghana, Kenya, and to a lesser extent, Malawi and Mali. The diaspora externality has smaller albeit non-negligible effects; it divides the income loss by 2 when the externality operates in both sectors (Figure 3.6.e). As for the high-skilled, the income gain is divided by ten when schooling externalities are accounted for. High-skilled workers experience average income losses in Benin, Botswana, the Republic of Congo, Guinea, Nigeria, Tunisia and Zimbabwe. On the contrary, the diaspora externality has much smaller effects.

Figure 3.6: Results with technological externalities

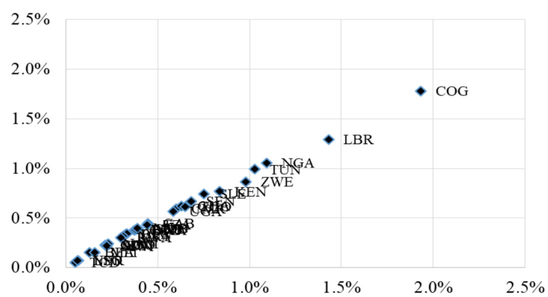
(a) 3.6a Schooling ext. on A_F only ($\frac{\Delta \overline{w_L}}{\overline{w_L}}$)



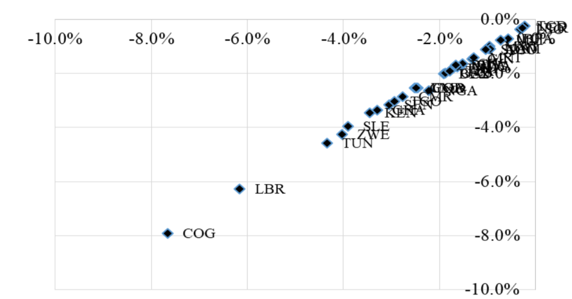
(b) 3.6b Schooling ext. on A_F only ($\frac{\Delta \overline{w_H}}{\overline{w_H}}$)



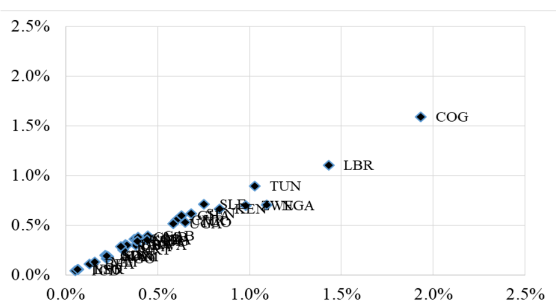
(c) 3.6c Schooling ext. on A_F and A_I($\frac{\Delta \overline{w_L}}{\overline{w_L}}$)



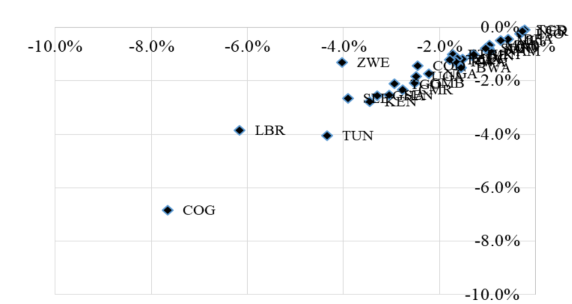
(d) 3.6d Schooling ext. on A_F and A_I($\frac{\Delta \overline{w_H}}{\overline{w_H}}$)



(e) 3.6e Diaspora ext. on A_F and A_I($\frac{\Delta \overline{w_L}}{\overline{w_L}}$)



(f) 3.6f Diaspora ext. on A_F and A_I($\frac{\Delta \overline{w_H}}{\overline{w_H}}$)



Extension with endogenous social mobility. – Finally, in line with the recent *brain gain* literature (Mountford 1997; Stark et al. 1997, 1998; Beine et al 2001, 2008), emigration prospects can stimulate the expected return to education, and increase the fraction of young adults acquiring education. In our benchmark model, the acquisition of human capital is reflected by the exogenous variable ρ, which measures the fraction of the low-skilled population becoming high-skilled at each moment in time. In this extension, we endogenize ρ and let it respond to changes in skilled emigration. We assume that low-skilled workers can invest an amount E in training to increase the probability of joining the pool of high-skilled workers and earn higher income. The probability of success can be expressed as:

$$\rho = \left(\frac{1}{a}E\right)^{1/\gamma},$$

which implies that reaching a probability ρ requires an investment of $E(\rho) = a\rho^{\gamma}$ (i.e., the training cost is increasing in ρ).

To simplify the analysis, we disregard differences between formal and informal employees and assume that low-skilled workers choose ρ (or equivalently, E) so as to maximize the mean present value of income (net of training costs) in a coordinated way:

$$\begin{aligned} &\underset{\rho}{\text{Max}}\ (1-i_L)r\Omega_{F,L} + i_L r\Omega_{I,L} - E(\rho) \\ &\text{where } \left\{ \begin{array}{r} r\Omega_{F,L} = \omega_L - \delta_L(\Omega_{F,L} - \Omega_{I,L}) + \rho(\Omega_{I,H} - \Omega_{F,L}) \\ r\Omega_{I,L} = \omega_I + \lambda(\theta_L)(\Omega_{F,L} - \Omega_{I,L}) + \rho(\Omega_{I,H} - \Omega_{I,L}) \end{array} \right. . \end{aligned}$$

The first order condition for this maximization problem writes as

$$\rho = \left[\frac{(1-i_L)(\Omega_{I,H} - \Omega_{F,L}) + i_L(\Omega_{I,H} - \Omega_{I,L})}{a\gamma}\right]^{\frac{1}{\gamma-1}}, \tag{3.17}$$

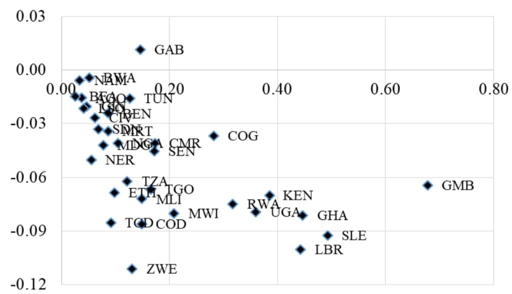
where the parameter γ governs the sensitivity of training decisions to income shocks.

We calibrate γ to be in line with the empirical literature on emigration and human capital formation. We simulate the same shock on p (dividing p by 2) in all countries and compute the elasticity of ρ (our proxy for pre-migration human capital investment) to p as -2$\Delta \ln \rho$. The empirical paper of Beine et al. (2008) provides an estimate of 0.05 for this elasticity. We thus choose γ in such a way that the mean elasticity -2$\Delta \ln \rho$ in our sample equals -0.05. This gives $\gamma = 9$. Once γ is fixed, we calibrate the country-specific level of the scale parameter a to match the benchmark level of ρ. We then add Eq. (3.17) into the model. Without shock, the pre-shock equilibrium is identical to that of the model with exogenous social mobility. In the counterfactual with $p = 0$, the extended model accounts for the change in training decisions. The first direct effect of setting $p = 0$ is that $\Omega_{I,H}$ decreases. Then, general equilibrium effects operate through (in)formal employment and wages levels.

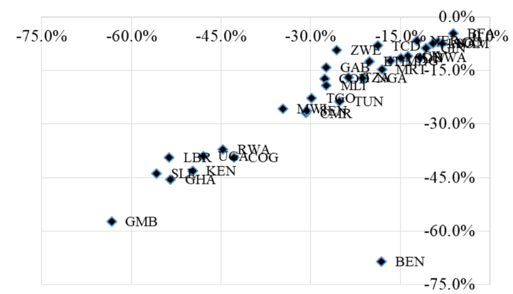
The results with endogenous social mobility are illustrated on Figure 3.7. Figure 3.7.a describes the relative change in ρ as a function of the baseline proportion of emigrants (P). On average, ρ decreases by 2% when the emigration rate falls by 10 percentage points. The effect varies across countries. Then, Figure 3.7.b compares the effect of high-skilled migration on the skill ratio with exogenous (X-axis) or endogenous (Y-axis) social mobility. The effect of the brain drain is obviously smaller in the model with endogenous social mobility, although we do not identify any case of net brain gain. On average, the human capital loss caused by the brain drain is 18% smaller in the context with endogenous ρ. Finally, Figures 3.7.c and 3.7.d compare the low-skilled informality and wage responses to the brain drain with exogenous (X-axis) or endogenous (Y-axis) social mobility. These labor market responses are slightly smaller when social mobility is endogenized but are qualitatively similar to our benchmark results. Our conclusions are thus robust to the brain gain mechanism.

Figure 3.7: Results with endogenous social mobility

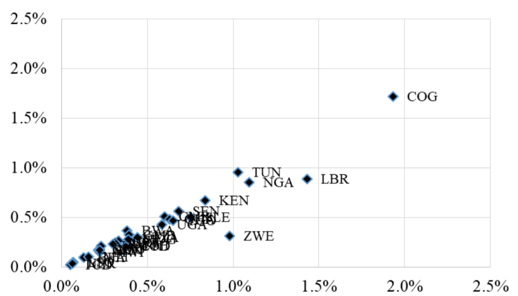
(a) 3.7a Training response and P



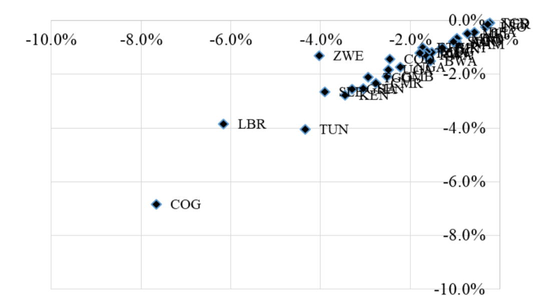
(b) 3.7b Effect on skill ratio



(c) 3.7c Effect on informality for low-skilled



(d) 3.7d Wage effect for low-skilled



3.4 Concluding remarks

This paper investigates the implications of skilled emigration for a subset of sub-Saharan African countries. We develop a model with two classes of workers and two-sectors (formal and informal) producing a homogeneous final good. In a competitive framework with perfect mobility across sectors, we show that the informal economy acts as a buffer zone that perfectly neutralizes human capital and emigration shocks. Skilled emigration increases the size of the informal sector but has no effect on income levels and inequality. Nevertheless, such a competitive model fails to explain the existence of persistent wage differentials between sectors as well as the presence of high-skilled workers in informality.

We thus develop an alternative search-and-matching model that is compatible with these facts, and we use it to revisit the welfare and inequality implications of the brain drain.

Our quantitative analysis suggests that skilled emigration increases the income and formal employment levels of the highly skilled. On the contrary, it decreases the welfare of the low-skilled. These welfare losses are highly heterogeneous across countries. This heterogeneity is mostly governed by cross-country differences in the training technology and in the relative productivity of the informal sector. Countries with low productivity differentials and good training technologies suffer more from the brain drain. In the other countries, emigration shocks are better absorbed by the informal sector. Our results are robust to identifying assumptions, to the inclusion of technological externalities, or to the endogenization of training decisions.

Chapter 4

The effect of norms on the intensive and extensive margins of fertility and its implications for the quantity-quality trade-off in Pakistan

This chapter investigates the effect of fertility norms on the extensive and intensive margins of fertility in Pakistan and infers its consequences for the education of children. The distinction between two margins yields results that are disregarded when solely the intensive margin is considered. Due to the lack of information on investment in education of children (quality) I make use of indirect inference to assess the quality. I first estimate an auxiliary econometric model and show a strong positive effect of fertility norms on both margins. Next, I develop a quantity-quality model augmented with the role of fertility norms. I identify the structural parameters of the model using the results of the empirical analysis. I then simulate the theoretical model and conclude that the $\frac{2}{5}$th of the variation in the quantity between the women with highest fertility and lowest fertility comes from difference in norms while the rest is explained by wage difference. Similarly, $\frac{1}{5}$th of the variation in quality between the two women is explained by the norms while the rest comes from difference in wage. Women with lower wages are more responsive to changes in norms in terms of changes in quantity-quality trade-off. On the other hand women's response to changes in wages is governed by norms. Higher norms mitigate the effect of economic development on both quantity and quality.

4.1 Introduction

The role of human capital in fostering economic growth and development in a country is well known. Education is one important determinant of human capital. The importance of education increases many folds in the context of developing countries like Pakistan where the challenges are more intense. The multidimensional poverty is one of the main concerns of Pakistan with 39% of the population living under multidimensional poverty.[1] The biggest contribution to national poverty stems from education in Pakistan. Education driven poverty contributes 42.8% to the national poverty (Multidimensional Poverty in Pakistan, 2016). Despite the situation, on a national level annual public expenditure on education has remained between $2 - 2.6\%$ of GDP over the last many years. This is smaller than the investment made by neighbouring countries like India, Iran and Nepal which on average spend more than 3% of GDP on education (WDI, 2016). Generally the education decisions are made during childhood by the parents. To design policies that cater to the needs of certain segments of the society, information is required on what determines the decision of a parent to invest in the education of her children. Unfortunately for Pakistan this information is missing. Investment in education of children (henceforth referred to as quality) is closely related to fertility decision and there is a big body of literature that explores this quantity-quality trade-off. It is difficult to investigate the quality decision of a mother without investigating her fertility behaviour. Fertility decisions in Pakistan are subject to high fertility norms of the society. This may affect not only fertility but the quality of children as well. The objective of this study is to explain variation in quantity-quality trade-off among women in Pakistan stemming from exposure to high fertility norms with a special focus on the decision to stay childless (the extensive margin).[2]

As mentioned, it is difficult to map a women's fertility to the corresponding quality of her children using the existing data. So, I employ indirect inference to retrieve data on quality. The idea of the strategy is to develop theoretical channels that predict how fertility norms affect the quantity-quality of children. To identify the structural parameters of the model an auxiliary econometric model is estimated to get stylized facts on fertility patterns of the women in Pakistan. The information from the empirical analysis is used to identify the structural parameters of the theoretical model. The theoretical model is then simulated to infer the quality of children. When it comes to fertility decisions it is not only factors like wages and wealth that influence fertility behaviour of women but fertility norms of the society also play a very important role in this regard. To better understand the fertility behaviour of the women of Pakistan and quantify the effect of norms and wage on fertility I first estimate the econometric model of fertility using "Pakistan Household Demographic Survey" (PDHS) data from 2012-13. I consider quantum norms for my analysis. Quantum norms are fertility norms related to the socially acceptable number of children including childlessness (Kl¨usener, Neels and Kreyenfeld, 2013; Balbo, Billari and Mills, 2013). The empirical model yields information on the extent to which education of the mother and norms that the mother is exposed to have an impact on the number of children ever born to her. I use these results to estimate the number of children ever born to women exposed to certain fertility norms and with specific education. Later, I use my theoretical model to replicate this behaviour and also generate information on corresponding quality of the children.

The first step for the empirical analysis is to find a measure of fertility norms. But before that I shall discuss briefly the idea of norms for this analysis. I construct two kinds of individual specific norms based on education and on ethnicity of the women in the sample. The ethnic

[1]Multidimensional poverty index is based on fifteen indicators. It was developed by Oxford Poverty and Human Development Initiative (OPHI) and the United Nations Development Programme in 2010.

[2]Norms and fertility norms interchangeably used in this study

fertility norms capture the persistent dimension of culture that identifies one ethnic group from the other. The idea behind the norms based on education is to capture the cultural innovation which may be specific to the educated segment of the society only. Since in Pakistan this group forms a very small proportion of the society, the cultural development within this segment is not observable when merged with the average behaviour of the society. These cultural developments may diffuse into the rest of the society as this segment expands. I have 8 ethnic norms based on the 8 ethnic groups classified in PDHS. For the education group I create four education groups namely, 1; uneducated 2; with some or complete primary education 3; with some or complete secondary education 4; with tertiary education which amounts to 13 years or schooling or more. The norms in each group are measured as the average of the total number of children ever born to women aged 49. The identification of norms is challenging. There could be several factors that make the identification of norms difficult but there are two key problems. Fist to identify norms it is important to disentangle the effect of norms from economic, institutional and political factors, second norms can be endogenous to fertility after all they are measured as the average number of children born to women who have completed fertility in a certain ethnic or education group. To deal with these problems I use a lagged measure of norms. I construct norms using PDHS data from 1990-91. This allows me to mitigate the identification problem arising from time-specific conditions the women face and from the endogeneity between norms and fertility. Note that the dataset for the analysis is 2012-13 which is used for information on fertility decisions and the rest of covariates. I use a zero-inflated poisson (ZIP) model to empirically analyse the effect of norms years of schooling and other covariates on fertility. ZIP allows to more clearly see the effect of norms and other covariates on extensive margin of fertility. ZIP also allows to differentiate between permanent and opportunity driven sterility. The results of the empirical model suggest that both ethnicity and education norms significantly affect the fertility level of a woman. The ethnic norms are more strongly affecting the fertility than the education norms.

In the next part of the analysis I build the theory using the quality-quantity model developed by de la Croix and Doepke (2003), I add the role of fertility norms as well as allow for childlessness. The model assumes that society inflicts an asymmetric cost on women who deviate from the norms. The women who are above the norms pay a relatively lower cost of deviation from norms than those who are below norms. This effect reflects a society where having no children or fewer children is costlier than having more children because of the stigma attached to childlessness and family planning. I also include wage and non-labour income in the theoretical model. The role of norms in the quantity-quality model is used to replicate the fertility behaviour that is observed in empirical part of the analysis. Norms affect fertility through social costs channel. In order to be closer to the the fertility norm preferred by society and minimise the cost related to it women choose higher fertility. Through this mechanism the norms also regulate the level of childlessness in the society. The asymmetric effect of norms on fertility thus ensures that childlessness either completely disappear or occur for infinitely higher wages. In this way higher fertility norms may dominate the effect of opportunity cost on childlessness. The opportunity cost of children is captured by wage. A higher wage means a higher opportunity cost o rearing and bearing a child and hence has a negative effect on the fertility level of the women.

To estimate the structural parameters of the model I use minimum distance procedure. This procedure estimates the structural parameters of the theoretical model such that the theoretical model replicates as closely as possible the fertility decisions estimated by empirical model in women exposed to different norms and different years of schooling. These parameters assist in generating information on quality of children across women in Pakistan. In the quantitative part of the study I simulate the model to first generate information on quality and decompose the fertility difference between women with least and most number of children into contributions by norms and opportunity cost. Then I run some counter-factual simulations to gather information on the effect of lower norms, higher wages and non-labour income on quantity-quality trade-off. The objective is to get an idea of how norms interferes with the effect of economic development on fertility. The results show that women of Punjabi ethnicity spend the most in education of their children with expenditure of highly educated women amounting to 5.51% relative to consumption expenditure in education. The uneducated Baruhi women have the highest fertility and they invest the least in the quality of their children. At most 58% of the variation in quantity is explained by wage while about 42% is explained by variation in norms. The quality varies at most by 80% due to difference in wage while the rest 20% of the variation is explained by norms. Lowering the norms increase the investment in education as well as reduces fertility in the society. Fertility behaviour strongly responds to changes in norms as well as changes in less educated women. Consequently, the change in quantity and quality is higher at low level of wages.

Literature suggests that social norms play an important role in shaping the individual behaviours (Thomson and Goldman, 1987; Akerlof, 1997) and these norms also regulate the fertility behaviour in a society (Dasgupta and Dasgupta, 2017). However, this is the first study to the best of my knowledge in the economic literature that evaluates the effect of fertility norms on the quality of children as well as on childlessness. This study adds to the limited evidence on quality-quantity trade-off and explains why some regions with same the level of development may show different quality-quantity trade-off. The existing literature on norms and fertility abstracts from including quality as well as avoid investigating childlessness. Recently though childlessness has become an important issue even in the context of developing countries. Studies by Gobbi (2013), Aaronson et al (2014) and Baudin, de la Croix, Gobbi (2015, 2017) include childlessness in the analysis. The argument is that to have a better understanding of demographic trends in a country it is important to investigate fertility along both intensive and extensive margins. Baudin, de la Croix and Gobbi (2017) show that the determinants of the two margins may be different. They show for example that fertility decreases with the education along the intensive margin while the relationship is inverted U-shaped in case of the extensive margin of fertility. Fertility increases along the extensive margin (reduced probability of childlessness) for initial levels of education and after reaching a minimum it starts increasing with a rise in education. Understanding such responses is important from the population and development policy viewpoints. I show in this study that childlessness also responds to norms and it is important to incorporate this response as it has implication for inequality. Higher fertility norms lead to higher number of children in low-skilled women.[3] These children are also poorly educated. The same norms in the society also prevent the high waged/highly educated women from having no children

[3]Low-skilled; women with no education or education below 13 years of schooling

despite the high opportunity cost.[4] This leads to at least one child in highly educated women who are also able to invest in the quality of their children. This leads to persistent inequality between successive cohorts. Kremer and Chen (2002) provide evidence that the fertility differentials between low-skilled and skilled women together with intergenerational persistence in education level make it difficult to reduce inequality in developing countries.

This study closely relates to the studies by Munshi and Myaux (2006), Fernández and Fogli (2006, 2009), Stichnoth and Yeter (2013), Spolaore and Wacziarg (2014) and Chabé-Ferret (2016). These studies examine the effect of cultural norms on fertility behaviour in a society. Munshi and Myaux (2006) provide evidence that high fertility behaviour and resistance to accept family planning in Bangladesh is strongly related to cultural norms. Fernández and Fogli (2006, 2009) show that the fertility of second generation of immigrant women in U.S. is positively affected by the culture in country of origin. They use fertility and labour force participation rates in country of origins as the proxy of culture. Stichnoth and Yeter (2013) find similar implication for fertility behaviour of migrant women in Germany. They allow migrant women from same origin to have heterogeneous norms based on the timing of migration. I also follow the idea of heterogeneous norms within a country in my analysis and assume that women from Pakistan are exposed to different fertility norms based on education and ethnic. Melkersson and Rooth (2000) also argue that individuals may be exposed to different social norms based on their social status. Therefore, they control for heterogeneous norms by using self reported social class of individuals as a proxy for norms while studying female fertility choices for Sweden. Chabé-Ferret (2016) provides evidence on the effect of norms observed in country of origin on the birth timing decisions of second generation migrant women in France and U.S. Spolaore and Wacziarg (2014) look at the transfer of norms from France to surrounding Europeans countries and provide empirical evidence that in some European countries fertility rate declined due to diffusion of lower fertility norms from France. Another study by Beine, Docquier and Schiff (2013) suggests that destination country's norms may possibly diffuse into countries of origin through emigrants and affect the fertility behaviour in the source country.

However, none of the above mentioned studies look at the effect of norms on the level of childlessness. Chabé-Ferret (2016) differentiates between the extensive and intensive margins of fertility but looks at *tempo* norms. *Tempo* norms are related to the timing of childbirth (Balbo, Billari and Mills, 2013). The study shows that cultural norms have no effect on the timing of first and second birth in second generation migrant women in France and U.S. But it does not say whether the overall level of childlessness is affected by the country of origin' norms. The economic literature mainly relates childlessness to economic factors like higher opportunity cost (Gobbi, 2013; Baudin, de la Croix, Gobbi, 2015; Aaronson et al, 2014) or poverty (Baudin, de la Croix and Gobbi, 2017). While the theoretical literature is quite clear on this issue, Aaronson et al (2014) is the only study to the best of my knowledge that analyses the quality-quantity trade-off while accounting for both extensive and intensive margin of fertility. This study however is not conducted in the context of norms and mainly looks at the economic determinants of childlessness.

Lastly, I could also compare the study to that of Hazan and Zoabi (2015). Their study

[4]Highly skilled; women with 16 years of schooling and above

suggests that highly educated women in U.S. may produce more children and work longer hours due to the availability and affordability of house keeping and daycare services. This study neither incorporates norms nor childlessness. In developing countries it is possible to observe highly educated women with children. It could possibly be inferred that these women are childless due to the channel described by Hazan and Zoaby but it may not be the case. The women may have children due to the stigma attached to childlessness. So to better understand the underlying causes of certain fertility patterns it is important to have a comprehensive framework which relates fertility to both economic and social factors and distinguishes between the two margins of fertility.

The rest of the study is organized as follows; section 4.2 discusses the empirical analysis; section 4.3 develops the theoretical framework; section 4.4 explains the identification of structural parameters and the results of simulations and section 3.5 concludes the study.

4.2 Empirical Analysis

This section specifies the empirical model and data set used in the empirical analysis. The idea behind conducting an empirical analysis is to get some stylized facts from data on effects of norms and wages on fertility. These facts are later used to estimate the structural parameters of the theoretical model.

4.2.1 Context

I use PDHS data set for year 2012-13 for Pakistan. Pakistan is a developing country where more than 95% of the population relates to Islam. Pakistan has observed very high fertility rates from between 7 and 6 till the end of 1980s. It witnessed a decline in fertility rate below 6 for the first time in early 1990s (Pakistan Demographic Survey 1992). Sathar and Casterline (1998) suggest that the fertility transition in Pakistan started in 1990s. The study suggests that important demographic changes began in 90s which were motivated by large scale social and economic changes that lead to changes in reproductive behaviour in this era. Among other determinants, the study suggests that female education may be one of the sources that initiated the break from reproductive regime which characterised Pakistan between 1960s and end of 1980s. The primary school enrolment ratio of females increased from 13% in 1960 to 30% in 1990. The primary school enrolment ratio rose to 65% in 2012.[5] This may reflect that a likely increase in the number of educated women in the country may have lead educated women to deviate from the prevalent higher fertility norms affecting reproductive behaviour first through opportunity cost and later reinforced by peer effect. Sathar and Casterline (1998) calls this change in fertility behaviour as the onset of fertility transition in Pakistan. Despite the economic and institutional factors reducing the fertility rate along the intensive margin (fertility rate dropped from 5.4 (PDHS, 1990) in 1990 to 3.83 in 2012 (PDHS, 2012-13)) they seem to have very little affect on childlessness. Childlessness

[5] http://www.unicef.org/infobycountry/pakistan_pakistan_statistics.html.

has in fact reduced since 1990s. In 1990s 3.3% of women aged 45 and plus were childless while in 2012-13 the fraction of childless women in sample reduced to 2.7%. These figures include both naturally fecund women and by choice fecund women (if any). Fertility norms may very well explain why this might have happened. Economic environment may have caused women to decrease fertility along intensive margin in face of increasing opportunity cost but norms may have prevented them from becoming completely childless by imposing a higher social cost of staying childless. Technological advancement may have helped avoiding childlessness. This is one probable reason why childlessness may have declined over time. I leave evidence to the empirical analysis.

Education in Pakistan is not completely subsidised and a large part of education expenses are paid by the parents. There are several types of education systems running parallel in the country.[6] The main distinction is based on ownership, private or public, and medium of instruction, English or Urdu (Urdu is the national language of the country). Public and Urdu medium schools are cheaper compared to the private and English schools and quality of education provided in private schools is considered superior to that provided at public schools. Private schools charge different fees based on their claim to quality of education they provide. They work more like brands and the richer a parent is the more expensive brand in terms of schooling her child wears. While the elite class of the country is almost always sending their children to privately owned expensive schools there is now an increasing trend in the middle class to send their children to a reasonably good school in terms of quality of education. One out of three students in Pakistan goes to private schools (Nguyen and Raju, 2014). The parents can choose a school according to their financial circumstances. Poor of the country on the other hand are most likely to either send their children to cheap (in terms of expenditure) public schools or not send them to schools at all. Being a developing country with an overall high fertility rate and with different systems of education to choose from makes the quality-quantity trade-off easy to observe and makes Pakistan suitable case for my analysis.

4.2.2 Data

The fertility in the empirical part is presented by the number of children ever born (NCEB) to a woman. The unit of analysis for empirical part of the study is woman. I shall analyse a sample of ever-married women aged 15-49. The sample has women from four major provinces of Pakistan namely 1) Punjab (Pun); 2) Sindh (Si); 3) Khyber Pakhtoonkhwa (KPK); 4) Balochistan (Bal). I use information on the years on schooling as a proxy for wage. The more educated are assumed to correspond to a higher wage group and less educated to a lower wage group. 59% of the women in sample have not received any formal education at all. The non-labour income is measured by ownership of assets. Only 16% women own assets either independently or jointly with the spouse. The last and most important factor characterising a woman is the level of fertility norm she is exposed to. The most important task here is to construct norms for women in the sample.

[6] I do not consider Madrasa-education system (Islamic seminaries providing religious education) in this analysis

There are several factors one needs to keep in mind while thinking about the norms but first and most important of all, there is no perfect way of constructing norms. I shall construct norms bearing in mind three hypotheses proposed by Manski(2000) while explaining similar behaviour among individual. These are

"1) endogenous interactions, wherein the propensity of an agent to behave in some way varies with the behavior of the group; 2) contextual interactions, wherein the propensity of an agent to behave in some way varies with exogenous characteristics of the group members; 3) correlated effects, wherein agents in the same group tend to behave similarly because they have similar individual characteristics or face similar institutional environments", Manski (2000).

It is difficult to disentangle these effects but to capture endogenous interactions and contextual effects I construct norms based on education and ethnicity. An individual can be exposed to different norms based on several different factors. I argue that norms may vary not only based on ethnicity but also with variation in the type of networks of individuals. For example a woman belonging to an ethnic group may be exposed to very high fertility norm in her ethnic group but if she is educated she may observes a lower fertility norm among her peers. This individual would then be affected by more than one norm. These different norms may very well be affecting her fertility decision in opposite directions. The fertility norm of the ethnic group might push her fertility upwards while the norm from her peers may be affecting her fertility choice downwards. This individual is not only exposed to different and opposing norms but also her exposure to norms is different from another women who has the same the ethnicity but is uneducated and observes a higher fertility norm both in her ethnic group and among her peers. So, I define two types of norms for my empirical analysis namely 1) Ethnic Norms based on the ethnicity of the woman 2) Education Norms based on the education group of the woman.[7] Norms based on ethnicity would carry the effect of cultural, lingual and ethnic characteristics that are transferred from one generation to another and affects the daily lives and characterize the people in that group. Education norms are important in capturing the transition in norms. Educated women form a small proportion of the society in Pakistan. If this segment of society is not analysed separately we may miss the cultural innovation and development that may be locked into a small segment of society but may diffuse via education networks across the society. So, the overall norms N_i could be expressed as a function of two norms$N_i = f(N_{Li}, N_{Ei})$ where N_{Li} are individual specific ethnic norms while N_{Ei} represent individual specific education norms. I use subscript L for ethnic norms so it is not mistaken for education. Note that the effect of education norm should not be confused with the effect of own education of a woman on her fertility. Her own education level would affect her fertility decision due to the time opportunity cost she has to pay for an additional child but the education norm would affect her fertility decision through what Manski (2000) calls endogenous interactions and contextual effects.

I first regress the fertility of women on age dummies using OLS. Using the result of this regression I predict fertility for each woman at age 49. I then create four education groups based on level of schooling namely 1) No education; 2) some or completed primary; 3)some

[7]It is possible to construct norms based on social networks, access to media and contraceptives etc but I believe that education is the most important factor which also affects the afore mentioned factors. So I base norms on education

or completed secondary; 4)higher education. I then compute average fertility for women at age 49, weighted by sampling probability as peer group norm for each education group.I have four types of norms based on education group. These education groups are formed on the national level rather than regional or district level in order to avoid correlated effects. Forming the groups across another dimension along with education, for example region, would lead to two problems first it may lead to very few observations in an education group belonging to a certain region and hence result in reflection problem. Secondly, taking norms in an education group that belong to same region may also lead the norm to capture the correlated effects as the women in these groups would be very homogeneous not only in terms of education but also in terms of exposure to same labour markets, similar environments and institutions etc. This means that the behaviour of females in a group with same education and from same region may vary with the behaviour of the group not because of their social interactions but because they are lets say exposed to same labour markets and same economic and political institutes. Creating norms nationwide across different education groups with no regard to region would minimise this probability to some extent and give variation in terms of exposure of females in same education group to different economic, political and physical environments.

For ethnic norms there are seven main groups defined in PDHS and an eighth group is defined as "others" and include all minority ethnic groups without clearly identifying them. I have 8 ethnic groups and I compute average fertility women at age 49 weighted by sampling probability as ethnic norm for each ethnicity. This gives me a total of 8 ethnic and 4 education norms.

One may still think that these norms could be capturing other correlated effects like education or labour market situations etc. To mitigate the identification problem further employing the notion put forward by Fernández and Fogli (2009) that norms persist over time I use data from PDHS 1990-91 to construct the above mentioned norms. This means that the values for these norms would at least not reflect the labour markets, education situations or any other time-specific characteristics of the region for individual under study. So these are more likely to capture the norms effect on fertility and quality choices of females as economic conditions captured by these norms are no longer relevant for individuals in 2012-13. The data available for 1990-91 unfortunately does not have information from the capital Islamabad and Gilgit Baltistan. Only in 2012-13 wave these two regions were included in the PDHS. That is why I exclude these two regions from my analysis. Both education and ethnic norms are weighted by there sampling probabilities to represent underlying population. Table 4.1 shows the distribution of norms across different ethnicities and education groups.

I have a sample of 10,884 observations from PDHS 2012-13 and the summary statistics of the main variables used in the analysis are given in table 4.2. The sample consists of married women only and does not include widows, divorced or separated women. The minimum value of education norm is 4.66 which corresponds to the skilled group depicting a lower fertility norm for more educated females.[8] Ethnicity norm ranges between 6.62 and 7.54. Dependant variable for the analysis is the number of children ever born (NCEB) to a woman. The minimum is 0 while the maximum is 19. Baruhi ethnic group clearly has a much bigger

[8]skilled group; 13 years of schooling and above

Table 4.1: Norms across ethnic and education groups

Ethnicity	Value	Percentage of sample
Punjabi	6.62	19.71
Others	6.63	6.70
Urdu	6.72	15.46
Baluchi	6.78	4.94
Sindhi	6.94	12.14
Pashtu	7.05	25.10
Saraiki	7.18	10.88
Baruhi	7.54	5.07
Education by years	Value	Percentage of sample
None	6.94	58.90
1-5 years of schooling	6.70	13.60
6-12 years of schooling	6.09	21.89
13 and more years of schooling	4.66	5.60

mean NCEB than other ethnicities which also corresponds to the higher norms observed in this ethnic group. Remember that the stats in table 4.2 are for women between age 15 to 49 while are norms are constructed for women at age 49 to capture norms based on completed fertility.

4.2.3 Econometric Model

The most commonly used estimation technique involving count data is Poisson regression model (PRM). PRM seems appropriate for empirical analysis of fertility behaviour but if we observe too many zero values taken by dependant variable (the number of children ever born in this analysis) then PRM turns outs a poor fit as it under predicts the zeros in the data (see Long and Freese, 2001 for details). The zeros in data could be either structural or sampling zeros. In the context of fertility structural zero would be permanent sterility and sampling zero refers to opportunity driven childlessness or childlessness due to young age etc. It is not possible to deduce which zeros are structural because some young women in specific might show zero fertility but this might be one possible outcome and as age increases this zero may disappear for certain women. On the other hand in some women it may represent structural zero and fertility may stay zero as these women reach the age of completed fertility. I have about 1335 zero observations in the data set. PRM also puts a very strong restriction on data as it does not allow over dispersion. I shall employ the Zero-inflated Poisson regression model (ZIP) introduced by Lambert (1992) which allows to predict probabilities for both sampling and structural zeros. It not only assists to overcome the under-prediction of zeros but also allows for over-dispersion as it changes the mean structure and uses two distinct process to generate zeros (for details see Long and Freese, 2001). It means unlike PRM, ZIP does not require $\overline{n} = \sigma$. Where $\overline{n}$ is the mean value of fertility in a sample and σ is the variance. ZIP assumes that there are two latent groups one that is a always zero A and

Table 4.2: Descriptive Statistics

Variable	Mean	Sd	Min	Max
NCEB total	3.7	2.76	0	19
NCEB Urdu	3.14	2.42	0	14
NCEB Punjabi	3.54	2.54	0	16
NCEB Sindhi	3.86	2.99	0	16
NCEB Pashtui	3.79	2.73	0	19
NCEB Baluchi	3.84	2.81	0	14
NCEB Baruhi	4.88	3.31	0	14
NCEB Saraiki	3.84	2.87	0	14
NCEB Others	3.59	2.75	0	13
Years of Schooling	3.50	4.82	0	16
Education %age sample				
	No education	Some or complete primary	Some or complete secondary	Higher
	58.90	13.60	21.89	5.60
Region %age sample				
	Punjab	Sindh	KPK	Balochistan
	32.97	25.71	23.94	17.38
Wealth index%age sample				
Poorest	Poor	Middle	Rich	Richest
18.37	19.04	19.14	19.55	23.90

other that is not always zero B. $A = 1$ if n_i is always zero and zero otherwise. First it predicts the membership in each group. It runs a logit/probit to determine the probability of an observation in the structural zero group. It then estimates the probability of each count including zero in not always zero group. In the last step it combines the probabilities from the previous two steps to predict the overall probability of a zero and non-zero counts. I shall estimate the parameters of following ZIP model:

Logit for always zero group

$$\psi_i \equiv Pr[A_i = 1|Z_i] = \frac{e^{Z_i\gamma}}{1 + e^{Z_i\gamma}} \tag{4.1}$$

Poisson for sampling zero and positive count

$$E[n_i|X_i, Z, Ai = 0] = e^{X_i\beta}(1 - \psi_i) \tag{4.2}$$

The overall probability of a zero is then computed as follows

$$Pr[n_i = 0|X_i, Z_i] = [\psi_i x1] + [(1 - \psi_i)xPr(n_i = 0|Xi, Ai = 0)] \tag{4.3}$$

For the always zero group one has to specify variable that predicts the membership in always zero group. ZIP then runs a logit to determine the membership in always zero group. I choose age, square of age, ethnic norms, education norms and own education to predict membership in always zero group. These are called the inflate covariates and are presented by vector Z_i. These variables could be the same or different from the control variables of may be zero group (Long and Freese, 2001).

Where n_i is the number of children ever born to a woman i and β is the vector of estimated parameters and $\epsilon = 2.71828$ is the mathematical constant. X_i is the vector of the covariates. It includes both age and square of years of age to capture the non-linear relationship between fertility and age. There are about 34% women in the sample who have a different number of pregnancies compared to children ever born. To control for fertility differences due to stillbirths or terminated pregnancies I use a categorical variable which takes the value of 0 if there has been no still-birth or terminated pregnancy experience and 1 otherwise. It is expected that women who experienced stillbirths or terminated pregnancies would have higher number of children ever born compared to those with no such experiences. For the effect of education I use information on years of schooling. For non-labour income there is no information available. So I make use of information on assets in possession of a woman. This is information on any property that a women may own alone or with the spouse. Since information on its value is not available I use categorical variable which is 1 in case of positive assets and zero otherwise. I use the wealth index to capture living standards. Wealth index in DHS reflects in general the living conditions of respondent for example, access to type of water, possession of durable like bicycle, car etc, access to media and similar things. I also use region fixed effects. I follow Fernández and Fogli (2009) and Chabé-Ferret (2016) in my approach of controlling for additional variables. They recommend to control for variables which may have explanatory power in predicting the fertility behaviour of a woman since other variables would capture any effect that is not caused by norms and prevent the norms estimates from being upward biased.

4.2.4 Results

The results of estimation are presented in table 4.3. The coefficients in first column are coefficients of ZIP converted into percentage changes in expected count for not always zero group and percentage odds of always zero group, the latter group represents permanent sterility. The second column gives results in terms of expected log count. The third column shows the standard error w.r.t column two. The reference group is a married poorest female who lives in Balochistan, owns no assets and had no stillbirth or a terminated pregnancy.

Results fecund group

First I look at the effect of norms on fertility of not always zero group (from now onwards referred to as fecund group). Increasing the education norm by one unit would increase the fertility of the woman by 15.5% in fecund group. Although personal education has a significant negative effect on fertility, a significant positive effect of education norms shows

Table 4.3: Effect of norms on fertility

Variable	Percentage coefficient	Expected log count coefficient	S.E
Percentage change in expected count for those not always 0			
Years of schooling	-1.8[a]	-0.018	0.004
Education Norm	15.5[a]	0.144	0.031
Ethnicity Norm	24.1[a]	0.216	0.034
Age in years	27.7[a]	0.245	0.007
Square of Age in years	-0.3[a]	-0.003	0.000
Assets	-0.8	-0.008	0.016
Stillbirth/Miscarriage/Abortion	2.5[b]	0.025	0.011
Pun	-1.2	-0.012	0.029
Si	-1.7	-0.017	0.027
KPK	-5.7[b]	-0.056	0.027
Poorer	-3.2[c]	-0.032	0.018
Middle	-3.9[b]	-0.040	0.020
Richer	-9.7 [a]	-0.102	0.023
Richest	-16.8[a]	-0.184	0.027
Small city	-1.8	-0.018	0.023
Countryside	-5.2 [b]	-0.054	0.024
Constant	-5.9[a]	——	0.349
Percentage change in odds of always 0			
Education Norm	-23.0	-0.262	1.259
Ethnicity Norm	23.2	0.208	0.307
Age in years	-32.5[a]	-0.393	0.081
Square of Age in years	0.5[a]	0.005	0.001
Years of schooling	-9.5	-0.010	0.109

Note: The sample has 10,884 married women of which 1335 have zero children. For region fixed effects, wealth effects, assets effects and experience of a terminated pregnancy/still birth, dummy variables are used. The errors are robust and clustered over primary sampling unit. The reference category is poorest married woman from Balochistan living in a big city and has experienced no terminated pregnancy/stillbirth. (a: Significant at 99 percent confidence interval ,b: Significant at 95 percent confidence interval , c: Significant at 90 percent confidence interval)

that own years of schooling may be affecting the fertility of a woman downwards but if the fertility in her education group is rising it would put an upward pressure on her fertility. As observed in the data the high skilled group has a lower norm so the fertility of high skilled declines for two reasons; one due to own education thus high opportunity cost of child-rearing, second due to decline in fertility norm of high skilled. Similarly, the ethnic norms also has a positive relation with fertility. It suggest that if the fertility norm in a specific ethnic group increases by one child the woman from that ethnicity is expected to increase her fertility by a little more than 24.1%. So it appears that the ethnic norms are more strongly affecting the fertility decision of the women compared to the education norm. Both results are significant. A positive effect of both the norms on the fertility decisions of a woman reflects the well studied hypothesis that human behaviour is affected by social interactions and in turn affects the economic outcome (Manski, 2000; Guiso et al, 2006; Munshi and

Myaux, 2005; Spolaore and Wacziarg, 2014). Fertility norm is a common example in this literature. A higher fertility norm would lead to higher fertility despite the fact that it leads to inefficient economic output, and it may be widespread (Guiso, et al, 2006).

The effect of own education on fertility is negative and an additional year of schooling decreases the fertility by 1.8%. The negative effect of education complies with the literature that suggests that education reduces fertility as educated parent bears a higher opportunity cost of child rearing(Barro and Becker, 1989; Livi-Baci, 1997; Kremer and Chen, 2002; de la Croix and Delavallade, 2018). The effect of assets which reflects the non-labour income here is insignificant. Experience of stillbirth increases the fertility by 2.5%. It is intuitive as women who experience still births or have children who die at an early age would have a higher NCEB in order to have a desired number of living children and they would attempt to reproduce more than the women with no such experiences. The region fixed effects are significant only for KPK and it has a lower fertility compared to the reference woman in Balochistan. Coefficient for wealth index dummies are significantly different from zero only for richer and richest women. Poorer and middle class woman's fertility does not differ significantly from poorest woman. A higher wealth index would not only mean better living standard but also better access to technology and probably more awareness about fertility control methods etc which may be why the richer and richest have lower fertilities compared to others. The effect of age is significant and positive. While the square of age has a negative relation with fertility.

Results permanently sterile group

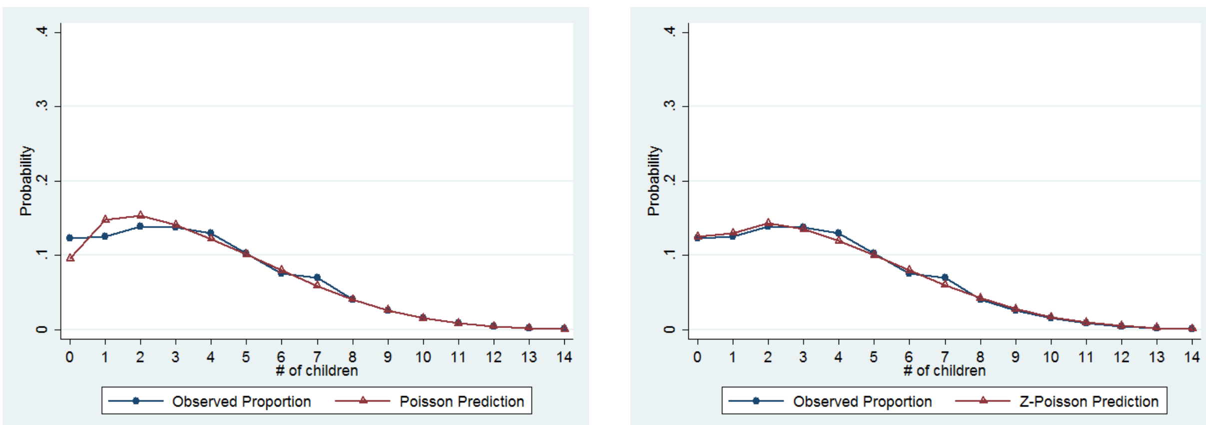
The results for always zero group (permanently sterile group) in the lower part of table 4.3 gives the percentage chances of permanent sterility for a woman based on age, age square, education, ethnicity norms and education norms. Age is the only significant factor affecting permanent sterility.

Childlessness

Combining the results for fecund and permanently sterile group gives the total probability of being childless. It appears that norms have a significant impact on fertility not only along intensive margin but along extensive margin as well. Norms increase fertility along extensive margin by affecting opportunity driven childlessness. The results shows that norms play an important role in preventing childlessness in developing countries exposed to higher fertility norms.

Using the probabilities from count model and always zero group I generate the overall probability of childlessness for women exposed to different norms and with different years of schooling. The results are shown in the table C1 and C2 in Appendix. For the effect of education on childlessness my results are similar to those found by Baudin, de la Croix and Gobbi (2017) for developing countries. The probability of childlessness decreases for increases in education at initial level reaching a minimum of 0.118 at six years of education and it starts increasing for education 8 years and more. Hence the fertility increases along extensive margin for initial levels of education while it starts decreasing after 12 years of education. It may be noticed however that the probabilities of childlessness are very low in general even for high level of education once again pointing towards the role of norms. To compare the performance of PRM with ZIP in predicting zeros accurately I plot probability of predicting zeros for the two models in figure 4.1. The left panel shows the results of PRM while the right panel shows the results of ZIP. The graphs plot the probability (y-axis) against the number of children(x-axis) from zero to 14. The blue lines are observed proportion while red lines show the proportion predicted by PRM or ZIP. It can be noted that PRM clearly under-predicts zeros.

Figure 4.1: Zip better predicts zeros



4.2.5 Robustness

In this section I discuss the robustness tests. The results for all robustness checks are given in appendix. One of the concern regarding the results in the preceding section could be that I use data on all women including those who have not yet completed fertility so the results might not be truly representative of the fertility behaviour of women with completed fertility. For this I do a robustness check running ZIP for women aged 40-49. Table C3 in appendix contains these results.The results are robust for intensive margin although the estimates change in magnitude.

In an additional robustness check I control for education of spouse and age as fertility of the woman may not only respond to her own education but also to the education of her partner. In this regression I also control for age at marriage. The results are robust to the age and education of spouse (see table C4 in appendix). The education of spouse has a negative effect on the fertility of women which may reflect the fact that men may also bear some opportunity cost of raising the children. The smaller coefficient shows that this cost is smaller compared to that born by mothers. The coefficients related to the age of spouse are also significant reflecting that fertility of women is also affected by the age of the spouse.

In the last robustness check I attempt to take care of the endogeneity problem between education and fertility. Students in Pakistan usually complete their Bachelor's degree at the between age 19 and 20. This amounts to 14 years of schooling. As I defined highly educated women those with at least 13 years of education to check the robustness to education I run the same regression on a sample of women who gave birth to the first child at the age 20 or above. The results are presented in appendix in table C5. The result for not always zero group are robust although for always zero group ethnicity norm is not robust.

4.3 Theoretical Framework

I build on the quantity-quality model developed by de la Croix and Doepke (2003). I consider an economy populated with heterogeneous individuals characterized by the wage (w_i), non-labour income (R_i) and fertility norms (N_i). Wage depends on the level of education of the individual. Individuals maximizes utility by choosing level of consumption (c_i), number of children (n_i) and the quality (e_i). The quality of children is determined by investment in education of children. Education has a fixed positive cost p per unit. It is a partial equilibrium analysis where w_i, R_i, p are exogenous. The utility function of an individual is given as follow

$$U_i = \log c_i + \theta \log[(n_i - \pi N_i) + a_1] + \lambda \log[e_i + a_2] \tag{4.4}$$

N_i represents the fertility norms of individual i. The parameter π represents the intensity of effect of norms. As I constructed two norms in the empirical analysis so I define the overall norm N_i here as a linear combination of two norms $\pi N_i = \pi_L N_{Li} + \pi_E N_{Ei}$. N_L is the ethnicity norms while N_E represents the education norm. π_L and π_E is the intensity of effect of norms associated with ethnicity and education norm respectively. In this model relative fertility rather than absolute fertility is important for utility. This is because with this utility formulation I want capture the fact that norms inflict an asymmetric cost on individuals above and below norms. This formulation with asymmetric cost of deviation from norms reflects a society which stigmatizes childlessness or use of contraceptions for family planning. Spolaore and Wacziarg (2014) also assume asymmetric effect of norms on utility of individuals. The individual with higher fertility would pay less for deviating from norms than those with lower fertility for given π if the society more readily accepts higher fertility. As $\frac{\partial U_i}{\partial n_i} > 0$, a higher number of children yields higher utility.

The asymmetric effect of norm is an important feature of this model. Assuming symmetric effect implies that individual at the same distance above or below the norm will pay same cost of deviation. This may lead to an overestimation of childlessness or underestimation of fertility along intensive margin in a society which exhibits higher fertility norms. It should be noticed that individuals with higher fertility may not necessarily be better off than those with lower fertility as they lose in terms of investing less in quality of children. $\theta > 0$ and $\lambda > 0$ are the preference parameter for quantity and quality of children respectively. a_1 and

a_2 are auxiliary parameters added to the model to incorporate opportunity childlessness with restrictions $a_1 \geq \frac{1}{\phi}$ and $a_2 = 1$. These restrictions are added to the model to avoid log of negative and zero values. The budget constraint of the individual is represented as follow

$$c_i = w_i(1 - \phi n_i) - e_i p + R_i \tag{4.5}$$

The other set of restrictions are given as follow

$$0 \leq n_i \leq \frac{1}{\phi} \tag{4.6}$$

$$e_i \geq 0 \tag{4.7}$$

$\frac{1}{\phi}$ is the biological maximum of the individual. It is referred to as full specialization throughout the article. ϕ cannot exceed 1 as this is the total amount of time available to the individual to allocate between work and child bearing/rearing.

The utility maximization problem of the individual is given as follow

$$\max_{n_i, e_i, c_i} U_i[n_i, e_i, c_i] \quad \text{s.t.} \quad (4.5) \quad (4.6) \quad (4.7)$$

The utility maximization gives the following result

Proposition *There exist thresholds w_1, w_2, w_3, w_4, w_5 and $\overline{R}$ Such that if*

1. *$Max[w_1, w_2] \leq w_i \leq w_3$ then $\frac{1}{\phi} > n_i \geq 0$, $e_i \geq 0$ (Interior regime)*
2. *$w_5 \leq w_i \leq Min[w_4, w_2]$ and $R_i \leq \overline{R}$ then $\frac{1}{\phi} \geq n_i > 0$, $e_i = 0$ (No quality)*
3. *$w_i \geq Min[w_3, w_4]$ then $n_i = 0$ and $e_i = 0$ (Childlessness)*
4. *$w_i \leq w_5$ and $R_i \leq \overline{R}$ then $n_i = \frac{1}{\phi}$ and $e_i = 0$ (Full specialization without quality)*
5. *$R_i \geq \overline{R}$ and $w_i \leq w_1$ then $n_i = \frac{1}{\phi}$ and $e_i \geq 0$ (Full specialization with quality)*

Proof: See Appendix proof C.

Given the parameters of the model $\{\theta, \lambda, \phi, \pi, a_1, a_2\}$ and $\{w_i, R_i, N_i\}$ of women the thresholds in proposition are defined as follows

$$w_1 = \frac{a_2 p + R_i \theta}{(1+\lambda)(1 + a_1 \phi - \pi N_i \phi)}$$

$$w_2 = \frac{a_2 p + a_2 p \theta - R_i \lambda}{\lambda(1 + a_1 \phi - \pi N_i \phi)}$$

$$w_3 = -\frac{a_2 p \theta + R_i \theta}{\theta - (1+\lambda)(a_1 \phi - \pi N_i \phi)}$$

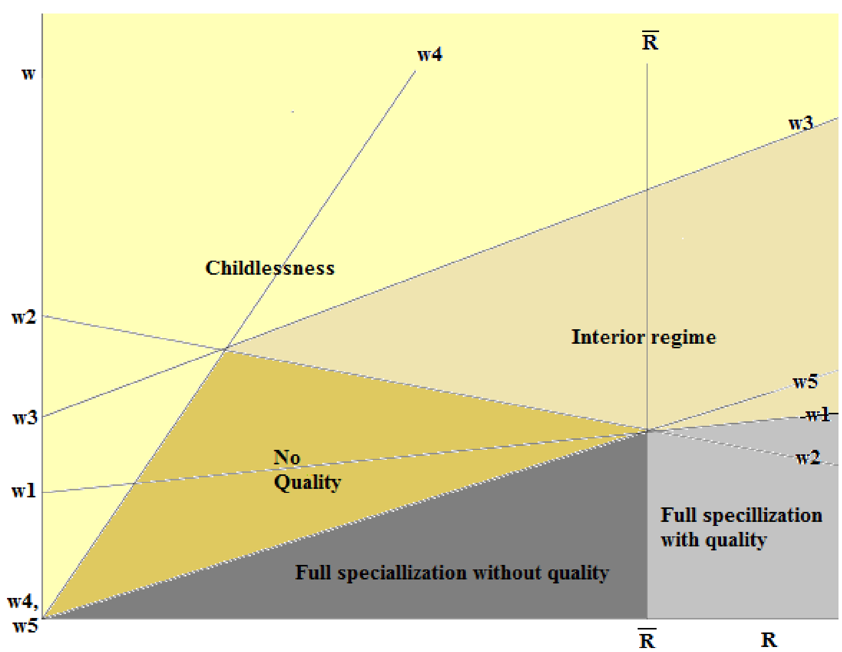
$$w_4 = -\frac{R_i\theta}{\theta - a_1\phi + \pi N_i\phi}$$

$$w_5 = \frac{R_i\theta}{1 + a_1\phi - \pi N_i\phi}$$

$$\overline{R} = \frac{pa_2}{\lambda}$$

Note that these critical wages are defined in terms of N_i and R_i so they will vary for individuals with different non-labour incomes and exposure to different norms in values. So it is not possible to rank them in a systematic order. w_1 is the minimum wage required to ensure no full specialization. w_2 is the minimum wage for providing education to children. w_3 and w_4 are the wage limits for opportunity driven childlessness. w_5 is the minimum wage below which agent fully specializes in fertility and does not supply labour. $\overline{R}$ is the limit on non-labour income above which parent could educate children even without supplying labour. Figure 4.2 shows the different fertility regimes in wage and non-labour income space. One can observe that as soon as the wage is above the maximum of w_2, w_1 individual will move from full specialization to interior regime even if the non-labour income is above $\overline{R}$. Similarly, in case the wage is above w_3 individual will move to opportunity cost driven childlessness even when above $\overline{R}$. We look at each case in detail in following sections.[9]

Figure 4.2: Fertility regimes in wage and non-labour income space



[9]See appendix proof C for proofs of all regimes.

4.3.1 Interior regime

When $\frac{1}{\phi} > n_i, e_i \geq 0$ then individuals are in interior regimes and quantity-quality can be defined as follows

$$n^* \equiv n_i = \frac{\theta(a_2 p + R_i + w_i) - w_i(1+\lambda)(a_1 - \pi N_i)\phi}{w_i(1+\theta+\lambda)\phi} \tag{4.8}$$

$$e^* \equiv e_i = \frac{-a_2 p(1+\theta) + \lambda(R_i + w_i + w_i(a_1 - \pi N_i)\phi)}{p(1+\theta+\lambda)} \tag{4.9}$$

Eq (4.7) shows the optimal value of n_i has a non-linear relationship with w_i. It reflects the fact that initially as wage increases the opportunity cost of having a child increases leading to lower fertility along the intensive margin. But if the wage is very high so that its income effect dominates the opportunity cost effect then fertility increases in wage. This later effect was explored by Hazan and Zoabi (2015) in women with very high wages. Fertility is increasing in non-labour income while the norms N_i also have a positive effect on fertility reflected by the following results

$$\frac{\partial n_i}{\partial N_i} = \frac{(1+\lambda)\pi}{(1+\theta+\lambda)} > 0 \quad \frac{\partial n_i}{\partial R_i} = \frac{\theta}{w_i(1+\theta+\lambda)\phi} > 0 \tag{4.10}$$

Results in eq (4.9) show that the quality of children reduces as the norm of parent increases. There is positive relationship between quality of children and wage of parent. Non-labour income also has a positive effect on quality. The individuals in this regime are indifferent to childlessness at wage equal to w_3.

$$\frac{\partial e_i}{\partial N_i} = -\frac{w\lambda\pi\phi}{p(1+\theta+\lambda)} < 0 \quad \frac{\partial e_i}{\partial R_i} = \frac{\lambda}{p(1+\theta+\lambda)} > 0 \quad \frac{\partial e_i}{\partial w_i} = \frac{\lambda(1+(a1-\pi N_i))\phi)}{p(1+\theta+\lambda)} > 0 \tag{4.11}$$

4.3.2 No quality

When $\frac{1}{\phi} > n_i, e_i = 0$ then n_i is defined as follow

$$n^\star \equiv n_i = \frac{R_i\theta + w_i\theta - a_1 w_i\phi + \pi N_i w_i \phi}{\phi(1+\theta)w_i} \tag{4.12}$$

In this regime individuals have positive number of children but they do not fully specialize if wage is above w_5. At wage w_5 they are indifferent between full specialization and producing children below maximum number possible. In this regime if the wage is below w_2 they cannot educate their children either. In this regime individuals cannot be childless as long as wage is below w_4, at w_4 the individuals in this regime are indifferent between staying childless and producing children. Remember that the individuals in interior regimes decide to stay childless above w_3. The As it is clear from (4.12) that in this regime as well the wage has a non-linear effect on fertility. It means the fertility may initially decrease with wage and then start increasing if the wage goes up by a large amount. While the following result suggest that fertility is positively affected by both norms and non-labour income in this regime.

$$\frac{\partial n_i}{\partial N_i} = \frac{\pi}{1+\theta} > 0 \quad \frac{\partial n_i}{\partial R_i} = \frac{\theta}{w_i(1+\theta)\phi} > 0 \tag{4.13}$$

4.3.3 Childlessness

In case of opportunity driven childlessness we have both $e_i, n_i = 0$. In this regime the value of wage should be high enough to ensure a higher opportunity cost of having children and the individuals decide to have no children. So as soon as the wage is above $Min[w_3, w_4]$ the optimal fertility level for the agent is zero. Note that the individuals in interior regime choose childlessness above w_3 while those in no quality regime choose childlessness when wage is above w_4. Since the critical wage is defined in terms of N_i and R_i, it is possible that the non labour income or/and norms are so high that it is not possible to have opportunity driven childlessness despite $a_1 > \frac{1}{\phi}$. Therefore, $a_1 > \frac{1}{\phi}$ is a necessary but not sufficient condition for the opportunity driven childlessness regime.

4.3.4 Full Specialization without quality

In this regime producing the maximum number of children ($\frac{1}{\phi}$) biologically possible becomes the optimal decision for the individual. In this regime R_i must be below $\overline{R}$ otherwise wage will not matter for investment in education of children. This regime is similar to no education regime as there is no investment in education of children. The difference is that in no education regime $n_i < \frac{1}{\phi}$.

4.3.5 Full specialization with quality

In this regime the agents may have very low wage but their non-labour income R_i could be sufficiently high so as to ensure positive investment in education of children. For individuals with very high level of non-labour income the no education regime vanishes. The education in this regime is independent of wage and is given as follows

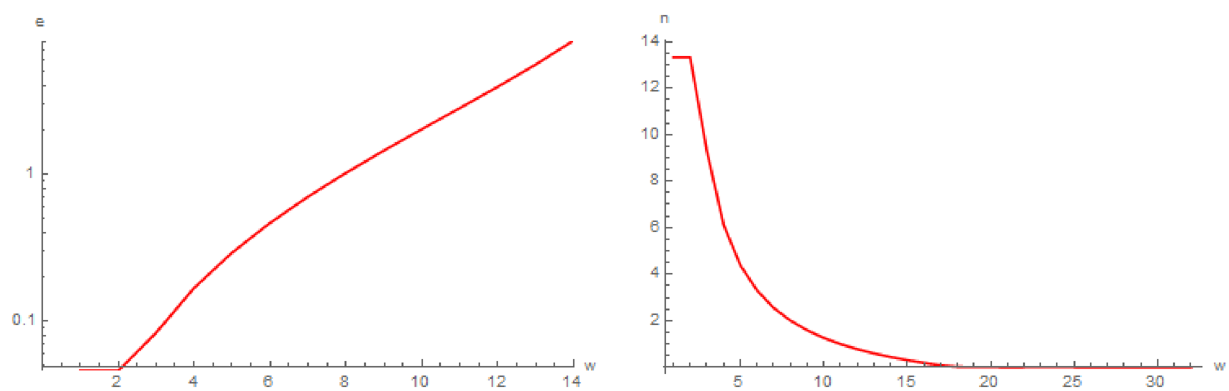
$$e_i^{\bullet} = -\frac{a_2 p - R_i \lambda}{p + p\lambda} \tag{4.14}$$

It can be observed that the investment in quality is not only independent of wages but it is also independent of norms. This is rather a simplified assumption as in case the price of education was dependant on wage (highly waged women choosing expensive private schools compared to low-waged women choosing public schools with lower cost) then the quality in this regime would also depend on wage. Education in this regime clearly increases as non-labour income increases.

4.3.6 Graphical representation of the regimes

Figure 4.3 shows the graphical representation of regimes discussed in preceding sections. The left panel on figure 4.3 shows a positive relationship between wages and quality for fixed values of norms and non-labour income. The flat part of the curve on the bottom shows no quality. The increasing part of the graph shows the education in interior regime. The right panel shows the negative relationship between fertility and wages. The upper flat part corresponds to regime with no investment in education of children and $n_i = \frac{1}{\phi}$. The part of the graph lying on the horizontal axis shows the opportunity driven childlessness. The rest of the curve shows interior and no quality regimes. Remember that when fertility becomes zero the curve for e_i becomes irrelevant, intuitively it is not possible to invest in quality of children when there is no child.

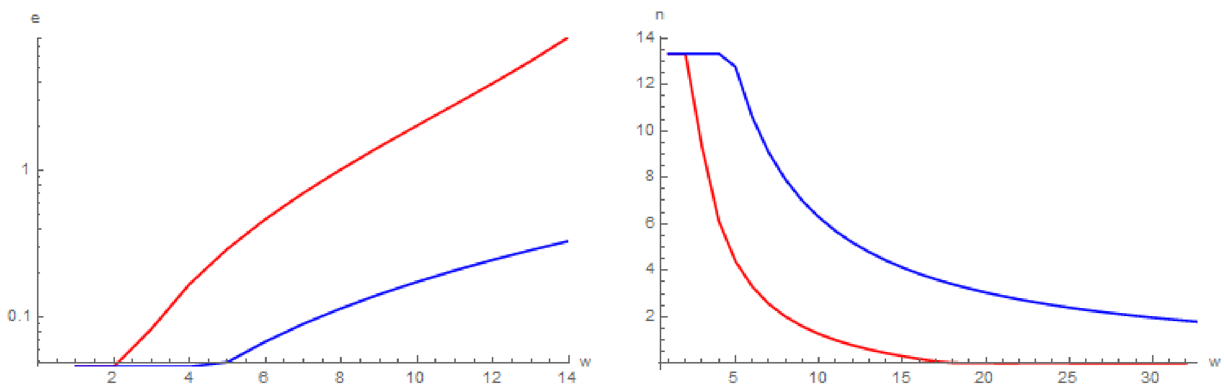
Figure 4.3: Different regimes of quality vs quantity of children



Effect of norms on childlessness

Figure 4.4 shows the effect of exposure to higher norms on quantity and quality. In both the panels the red lines show the initial levels while blue lines show the decisions when shocked by higher norms. In the left panel the curve for investment in quality of children moves rightwards as the fertility norms are changed to higher level. It reflects that societies with higher fertility norms would have lower quality of children. It is clear from the right panel of the figure that higher fertility norms increase the fertility and shifts the fertility curve upwards. It is quite possible to have societies where fertility norms are so high that it is impossible to have opportunity driven childlessness. When society reacts strongly to those childless individuals have a stronger incentive to avoid childlessness in order to avoid high costs. In this scenario the regime for childlessness would disappear.

Figure 4.4: Effect of high fertility norms on quantity-quality



4.4 Quantitative analysis

4.4.1 Identification of structural parameters

To identify the structural parameters of the theoretical model I set the values of some parameters a priori. The auxiliary parameters a_1 and a_2 are set at $\frac{1}{\phi}$ and 1 respectively. I fix $\phi = 0.05$ which gives a maximum number of biologically possible children equal to 20. Since there is no information on the wages I estimate the mincerian rate of return to map education into wages.

There are nine deep parameters namely; $\theta, \lambda, \pi_L, \pi_E, R, p, \varrho_1, \varrho_2, \varrho_3$ to identify. $\varrho_1, \varrho_2, \varrho_3$ give the estimated mincerian rates of return to primary, secondary and tertiary schooling respectively. The mincer rate of return for uneducated women is set at 0. The non-labour income could vary across women and that is why it is individual specific in section 4.3. But due to lack of information to extract individual specific values I shall estimate an average value of R. I use minimum distance estimation procedure for the identification of these parameters. I minimize the distance between 49 empirical moments and the moments generated by the theoretical model. To compute the empirical moments I use the results of empirical model to generate fertility values for women who have completed fertility (at age 49) for $4 * 8 = 32$ combinations of norms. Then using the same method I compute the fertility at age 49 for women with 0 to 16 years of schooling. This gives me 17 empirical moments based on opportunity cost. So, in total I have 49 empirical moments. The objective function estimates the structural parameters so as to minimize the distance between 49 moments described above and corresponding moments generated by the theoretical model. In addition I put a constraint that the weighted average spending on education by fertile women must equal the spending on education by government in Pakistan. This constraint does not include sterile women. This is because the theoretical model does not capture permanent sterility. The average education spending is weighted by the share of each type of women in the sample. I have 59% women with no education at all while a little below 5% have more than 13 years of education. I use information on aggregate public expenditure on education in Pakistan. Approximately a 2.5% of GDP was spent on education in Pakistan in year 2013. This will assists in extracting better information on investment in education of children by women. The objective function to minimize is as follows.

$$\min_{\theta,\lambda,\pi_1,\pi_2,\varrho_1,\varrho_2,\varrho_3,p,R} \left\{ \sum_{N=1}^{32} [{n_N}^* - {n_N}']^2 + \sum_{E=0}^{16} [{n_E}^* - {n_E}']^2 \right\} \quad \text{s.t} \quad E^* = (1-\chi)E' \qquad (4.15)$$

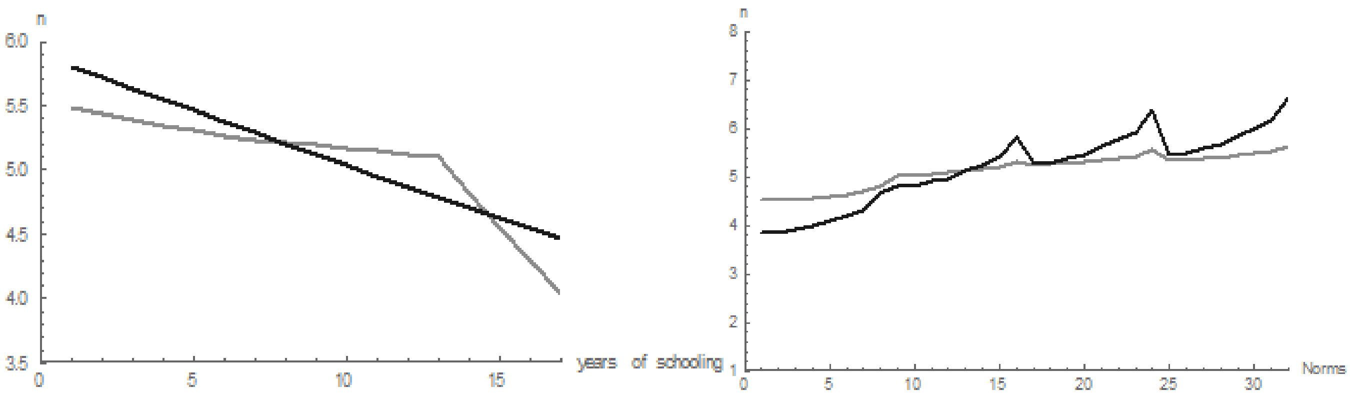
Where ${n_N}^*$ are the fertility values generated by empirical model for 32 values of norms and ${n_N}'$ are the corresponding fertility values generated by the theoretical model. Similarly, ${n_E}^*$ and ${n_E}'$ are the fertility values generated by empirical model and theoretical model respectively for the 17 values of wages. E^* represents the expenditure made by government on education as a percentage of GDP while E' is the weighted average expenditure made by women belonging to different education/wage groups as implied by the model. χ is the proportion of permanently sterile women as estimated by the empirical model. It has a value of 0.032. Table 4.4 shows all the parameters of the theoretical model. Figure 4.5

Table 4.4: Estimated and a priori fixed parameters

Parameter	Value	
a_1	20	fixed a priori
a_2	1	fixed a priori
ϕ	0.05	chosen to match the moments
p	0.47	estimated to match the moments
θ	0.62	estimated to match the moments
λ	0.32	estimated to match the moments
π_L	0.54	estimated to match the moments
π_E	0.45	estimated to match the moments
R	0.82	estimated to match the moments
ϱ_1	0.006	estimated to match the moments
ϱ_2	0.003	estimated to match the moments
ϱ_3	0.037	estimated to match the moments

shows how the fit of structural model to the data. The empirical moments generated for years of schooling assist in capturing the effect of opportunity cost on fertility while the empirical moments generated for norms assist in capturing the effect of norms on fertility. It is rather easy to see that these moments are meaningful in identifying $\theta, \pi_L, \pi_E, \varrho_i$. Now to understand how minimum distance procedure identifies λ, p, R imagine the role of λ in affecting fertility of women. When λ increases the quality will increase while quantity shall decrease. The minimum distance procedure shall estimate θ in order to simulate moments that are as close as possible to empirical moments. In order to achieve this the λ must be adjusted accordingly. If λ is too big fertility will be small and the moments generated by

Figure 4.5: Simulated moments (gray lines) versus empirical moments (black lines)



the model will be farther away from empirical moments. In a similar fashion the values of p and R shall be adjusted.

The interpretation of the values of the parameters is straight forward. p is the price of per unit of education and a rise in it's value will lead to a decline in quality. θ and λ are the preference parameters for quantity and quality respectively. A higher value of θ compared to λ suggests a society that puts more weight on quantity than quality. The estimated value of θ is almost double the estimated value of λ for Pakistani women. This reflects a higher preferences for quantity which leads to a lower quality. This is also evident in the overall situation of education of children in the country. The π_L is bigger than π_E which shows that the intensity of effect of ethnic norms is higher than that of education norms. This is also observed in the results of empirical model which shows ethnic norms play a bigger role in affecting fertility than education norms. R is the mean value of non-labour income for whole sample. A rise in R would increase both quantity and quality as they are both normal goods in my model. Notice that the three mincer rates of return ϱ_i are very small compared to what is found in the literature for Pakistan. The literature suggests a this rate varies between 5 to 7 percent for each additional year of schooling. [10] Here this very small rate of return also captures the probability of employment of a woman. The data set has no clear information on the employment status of the women throughout her reproductive years. In Pakistan the female labour force participation is very low and amounts to a mere 25%. This may be the reason why the estimated mincer rates are so small in value as they capture both returns to schooling and employment probability of women in different education groups.

4.4.2 Quality of children

The results in table C6 in appendix show the simulated fertility and investment in education (relative to consumption share) made by women belonging to different ethnic and wage groups. The values are estimated at relevant ethnic and education norm for each group. Remember there are four education groups as defined in section 2.2 and the values are for

[10]See Nasir and Nazli, 2000; Khan and Toor, 2003; Jamal et al, 2003; Hyder, 2007; Aslam, 2007

the women who have completed fertility. The results show that women of Punjabi ethnicity belonging to the highest wage group spend highest on education and have the lowest fertility of 3.32 children. The highest fertility of is observed in the women of Baruhi ethnicity with lowest wage. They also show a lowest investment in education of children. The expenditure on education is expressed as percentage share relative to expenditure on consumption.

The quantity and quality difference between the highly educated Punjabi woman and least educated Baruhi woman is +2.50 and −4.09 respectively. These differences could be driven by opportunity cost and/or norms. It would be interesting to quantify the contribution of norms and wage to the variation in quantity and quality across the two groups. Figure 4.6 shows the the role of norms versus opportunity cost in explaining the difference in quantity-quality between Punjabi and Baruhi women. The difference in wage 58% of fertility difference while it explains more than 80% of the difference in quality of children between the two type of women. Norms matter more in explaining the fertility differences than the quality of children. The two type of norms together explain more than one third of the difference in fertility between the two type of women. Less than one fourth of the difference in quality comes from the difference in ethnicity and education norms. The interaction of the norms and wages changes the fertility by 0.4% while changes the quality by 0.73%.

Figure 4.6: Contribution of norms and opportunity cost to variation in quantity-quality

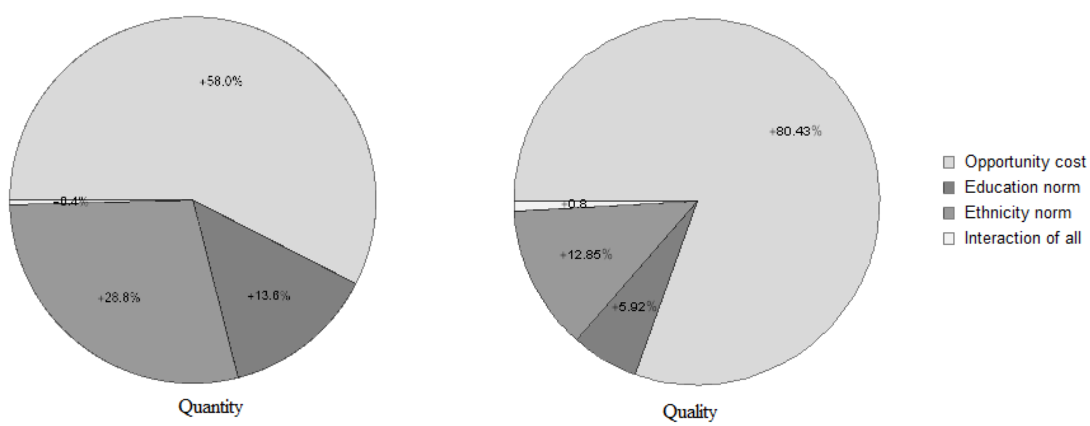


Table 4.5 gives the variation in quantity-quality as we move from a highly educated Punjabi woman to least educated Baruhi woman. The first row shows the quantity-quality for a highly educated Punjabi woman at ethnicity and education specific norms and wage while the last row shows the quantity-quality for a least educated Baruhi woman. The rows in-between show the changes in quantity-quality as we move the Punjabi woman closer to the Baruhi woman by changing norms and wages one at a time.

Role of education norms

To emphasize on the role of education norms I compare the women exposed to ethnicity norms to those exposed to both ethnicity and education norms. Figure 4.7 shows the quantity and

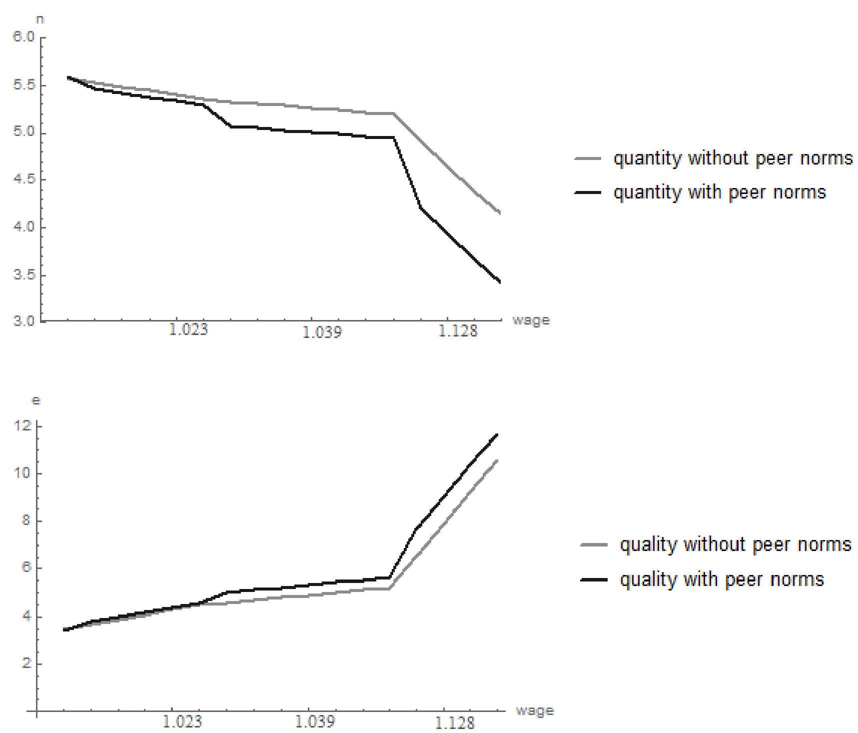
Table 4.5: Role of opportunity cost vs norms in explaining variation in quantity and quality across women

At values	Quantity	Quality	Change in quantity	Change in quality
$N_L = 6.62$, $N_E = 4.66$, $w = 1.215$	3.32	5.51	—	—
$N_L = 7.54$, $N_E = 4.66$, $w = 1.215$	3.66	5.27	+0.34	-0.24
$N_L = 6.62$, $N_E = 6.94$, $w = 1.215$	4.04	4.98	+0.72	-0.53
$N_L = 6.62$, $N_E = 4.66$, $w = 1.000$	4.77	2.22	+1.45	-3.29
$N_L = 7.54$, $N_E = 6.94$, $w = 1.000$	5.82	1.42	+2.50	-4.09

Note: Quality is expenditure on education of children expressed as a percentage share relative to the expenditure on consumption.

quality with and without the effect of education norms. The darker lines in the figure shows the quantity-quality when women differ both by wage and by education norms while the lighter lines show women only by wage. Assuming women are only affected by one kind of fertility norms (the average fertility norm, 6.9) in the society and disregarding the effect of education' norms leads to an over estimated fertility while the quality of the children is underestimated for each wage/education group. The idea of this exercise is to show that education not only affects the quantity-quality trade-off through opportunity cost but also through peer effect.

Figure 4.7: Role of education norms in explaining variation in quantity-quality



All the results in this section are calculated at the mean value of non-labour income as identified by the minimum distance procedure. But the individuals may differ in terms of non-labour income. In the next section I simulate the model to investigate how a variation in non-labour income may lead to different implications for quantity-quality trade-off.

4.4.3 Simulations with non-labour income, wage and norms

Lowering the norms

In this section I run a counter-factual simulation to understand how lower norms will affect the quantity and quality of children in Pakistan. Table 4.6 shows the results. In the first column under fertility and quality the ethnic norms are set at 6.9 for all women while the $N_E = i$ (where $i = 6.94, 6.70, 6.09, 4.66$) represent education norms which vary as we move from one education group to another. In the second columns for fertility and quality I set both ethnicity and education norms at the replacement fertility rate of 2. The results show that lowering the norms reduces quantity and improves quality. Lowering the norms reduces the social cost of deviating from the norms which leads the time opportunity cost effect to operate at a lower level of wage as well. It may be noticed that the percentage change in quality (education relative consumption) is the highest for the women with lowest wage and decreases as we move to higher wage groups. The decline in fertility is biggest for the women with lowest wage -3.36 while it is smallest -2.63 for women with 13 years of schooling and more. This difference in fertility in response to lowering of norms across different education/wage groups comes from difference in education group norms. If both ethnicity and education group norms are set at 6.9 then the fertility declines by 2.35 children in all wage groups. This exercise also make the connection of childlessness to norms clear in the analysis. The women with highest wage get closer to childlessness when norm are lowered to replacement level. If childlessness is disregarded in the analysis then we ignore the women who could be childless had they been observing lower norms but currently cannot do so due to exposure to higher fertility norms. Figure 4.8 show more clearly the changes in share of expenditure on education relative to consumption. Lowering the norms to replacement level increases the average quality by 148% in the lowest wage group while it increases the quality by 32% in the highest wage group.

Figure 4.8: Percentage change in quantity-quality with lower norms

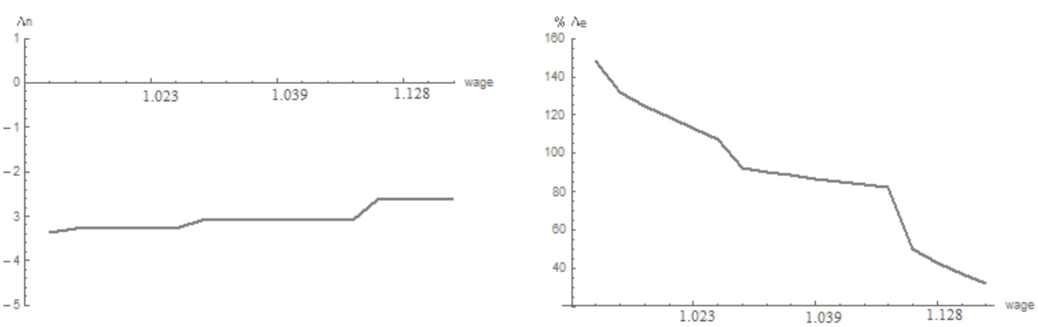


Table C7 in appendix shows the changes in quantity and quality as a result of decline in fertility norms to the replacement level for each ethnic group. The women with lowest wage belonging to Baruhi ethnicity gain the most in terms of quality of children from lowering the norms. They are able to increase the investment in education of their children relative to consumption expenditure by 180%. They also reduce the quantity of children by the highest number (-3.60) among all women. The women of Punjabi ethnicity and highest wage are least affected by the decline in norms both in terms of quantity and quality. They increase the quality by 30.52% while they reduce the quantity by 2.53 children. It is clear that less educated women are most affected by the changes in norms in terms of both quantity and quality.

Table 4.6: Fertility and quality of children with lower norms

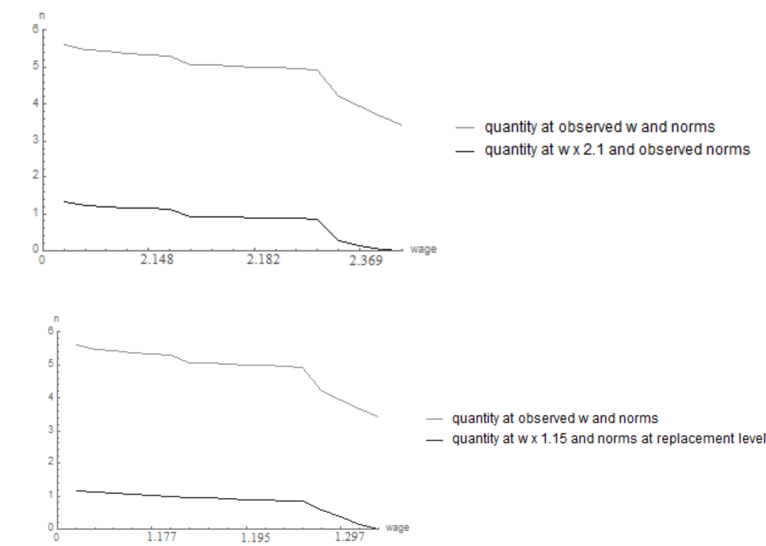
	Fertility		Quality	
Wage	$N_L = 6.9, N_E = i$	$N_L = N_E = 2$	$N_L = 6.9, N_E = i$	$N_L = N_E = 2$
1.000	5.59	2.23	1.60	3.97
1.005	5.47	2.18	1.75	4.07
1.011	5.42	2.14	1.85	4.16
1.017	5.38	2.09	1.95	4.26
1.023	5.33	2.05	2.04	4.35
1.028	5.29	2.01	2.14	4.45
1.0.31	5.07	1.99	2.33	4.49
1.034	5.05	1.96	2.38	4.56
1.037	5.03	1.94	2.43	4.59
1.039	5.01	1.92	2.48	4.63
1.043	4.99	1.90	2.53	4.68
1.046	4.96	1.88	2.58	4.73
1.049	4.94	1.85	2.62	4.77
1.088	4.20	1.57	3.58	5.39
1.128	3.93	1.30	4.21	5.99
1.171	3.68	1.04	4.82	6.59
1.215	3.42	0.79	5.44	7.19

Note: Quality is expenditure on education of children expressed as a percentage share relative to the expenditure on consumption.

Role of opportunity cost and norms in preventing childlessness

In this section I conduct a counter-factual simulation to analyse the effect of wage and norms on childlessness. To do this I first simulate the model at average level of ethnicity norms (6.9) and education specific education norms while increase the wage to the level which leads to opportunity driven childlessness in the most highly waged female. Inducing childlessness in the women with highest wage requires a rise in wage by a 110%. In the second simulation I set both ethnicity and education group norm at replacement level fertility of 2 children per woman. To induce childlessness in women observing the replacement level norms requires the wage to increase by only 15%. Remember that childlessness is an extreme case and analysing this case makes it more clear to understand the strength of the norms in society. If childlessness is tolerated in the society we might observe bigger responses on fertility along the intensive margin to changes in economic development. Figure 4.9 shows the results of the two simulations. The upper panel in the figure compares the fertility in women with same ethnicity and education norm for observed wage group to that of women observing same norms but a wage increased by 110% at each level. The lower panel compares the fertility in women with same ethnicity and education group norm for observed wage group to that of women observing norms at replacement level and a wage increased by 15% at each level. Though this clearly indicates that in Pakistan both low wage and higher norms are responsible for low level of childlessness but it also conveys the message that norms affect the response of fertility and quality to the economic development to a significant extent.

Figure 4.9: Change in quantity with norms versus wage



Role of non-labour income

The preceding section discusses the quantity-quality of children in each ethnic and wage group assuming each woman has the same non-labour income. Women may not have the same level of non-labour income. The data does not allow to get exact the information on the level of non-labour income, I estimate a mean level for all women in sample. However, in this section I simulate the fertility and education expenditure decision of women by assuming different values of non-labour income.

First it is important to discuss the idea of non-labour income R in the context of Pakistan. Like most of the developing Asian countries in Pakistan also there exist a joint family living arrangement. It reduces accommodation as well as utilities costs. Similarly, joint family system also provides support in terms of providing care services for children in absence of mother. All these benefits can be counted as a part of non-labour income. The system is well in place in country in general but in cities there exist possibilities of nuclear family arrangements. It is also possible that some women contribute more in providing such benefits, for example taking care of the rent of the family house etc.

So, considering the nature of non-labour income I simulate the model by setting R at the half of the estimated mean value 0.41, at 0.82 which is the estimated level of R and at 1.64 that is the double of the estimated non-labour income. I fix N_L and N_P at the average value of 6.9 for all women. The results are shown in table 4.7 and could be compared horizontally across the columns to see the effect of non-labour income on women with same wages. The R has a positive effect on both fertility and investment in children's education in all women. These results corresponds to the discussion in section 4.3. We know from the theoretical model that quantity-quality are positively affected by R. These simulations assists in quantifying the extent to which the quantity and quality are affected by non-labour income in different wage groups.

Table 4.7: Investment in quality of children with alternative assumption about non-labour income

	Fertility			Quality		
Wage	$R = 0.41$	$R = 0.82$	$R = 1.64$	$R = 0.41$	$R = 0.82$	$R = 1.64$
1.000	2.64	5.58	10.79	0	1.62	8.31
1.005	2.63	5.54	10.71	0	1.71	8.37
1.011	2.61	5.49	10.64	0	1.81	8.43
1.017	2.59	5.45	10.57	0	1.91	8.49
1.023	2.57	5.40	10.49	0	1.20	8.55
1.028	2.56	5.36	10.42	0	2.10	8.61
1.031	2.55	5.33	10.38	0	2.14	8.64
1.034	2.55	5.31	10.35	0	2.19	8.67
1.037	2.53	5.29	10.31	0	2.24	8.70
1.039	2.52	5.27	10.27	0	2.29	8.73
1.043	2.51	5.25	10.24	0	2.34	8.76
1.046	2.50	5.22	10.20	0	2.39	8.79
1.049	2.49	5.20	10.17	0	2.44	8.82
1.088	2.39	4.92	9.71	0	3.07	9.21
1.128	2.87	4.65	9.26	0	3.69	9.60
1.171	2.17	4.39	8.84	0.23	4.31	10.00
1.215	1.99	4.14	8.42	1.03	4.93	10.39

Note: The values are calculated setting N_L and N_{Ei} at average for all women. Quality is expenditure on education of children expressed as a percentage share relative to the expenditure on consumption.

4.5 Conclusion

Norms affect the fertility decisions of women in all societies. In the context of developing countries fertility norms are usually high and tend to increase the overall fertility rate in the society and reduce childlessness. In this study I put forward that norms may not only affect the fertility behaviour but it also has implications for the quality of children (measured in terms of investment in education of children by mothers). I conduct this analysis for Pakistan. The lack of availability of data on quality of children corresponding to the observed fertility of women does not allow to measure the variation in quantity-quality trade-off explained by fertility norms. To overcome this problem I employ indirect inference which allows me to infer about the quality of children by investigating the fertility behaviour of women in Pakistan. I first conduct an empirical analysis which explains the variation in fertility due to norms. I assume two kind of individual specific norms based on ethnicity and education of the women. The empirical analysis concludes that both norms are significant and may not only affect the intensive margin of fertility but also has an impact on extensive margin of fertility. Ethnicity norms have a stronger impact on fertility.

I then develop a theoretical model which postulates how fertility decision of women are affected by their socio-economic characteristics namely; wages, non-labour income and fertility norms. The theoretical model suggests a positive effect of norms on fertility and non-labour income while wages have a non-linear effect. The theoretical model identifies five fertility regimes; 1) childlessness, 2) interior regime, 3) no quality regime, 4) full specialization without quality, 5) full specialization with quality.

I use the facts obtained from the empirical model on the effect of norms and wages on fertility to identify the structural parameters of my theoretical model. After estimating the structural parameters of the model I simulate the model to generate quality of children for women with different education levels and different ethnic groups in Pakistan. It appears that women from Punjabi ethnicity spend the most in education of their children with expenditure of highly educated women amounting to 5.51% relative to consumption expenditure in education. The uneducated Baruhi women have the highest fertility and they invest the least in the quality of their children. At most 58% of the variation in quantity is explained by wage while about 42% is explained by variation in norms. The quality varies at most by 80% due to difference in wage while the rest 20% of the variation is explained by norms. I also do some counter-factual experiments by lowering the fertility norms. Lowering the norms increase the investment in education as well as reduces fertility in the society. Less educated women are more responsive in terms of changes in quantity-quality trade-ff to changes in norms and in wages. So, the change in quantity and quality is higher at low level of wages. Overall the main contribution of the study is explaining variation in fertility along both extensive and intensive margins due to norms and providing information on what mothers spend on quality of children based on their level of education and exposure to norms.

Chapter 5

Conclusion

International migration plays an influential role in shaping the demographic features of the world. Both source and host countries are affected by this phenomenon and there is a growing literature on the implications of international migration for socio-economic outcomes in source and host countries. Social norms also influence individual behaviour thus affecting economic outcome in a society. These norms regulates the demographic trends in a country and have consequences for human capital formation and welfare of individuals in a country. This thesis contributes to the literature by adding to the existing knowledge on the effects of international migration and norms on demographic trends, welfare, human capital accumulation and labour market outcomes in different economies.

The first chapter discusses the effect of immigration on natives welfare in Germany. Focusing on the recent 25% increase in immigration during 2012-16 the study shows an average positive effect of immigration on native's welfare. Assuming a two-sector economy with a tradable and non-trable good the study suggests that taking into account the labour market frictions and accounting for changes in the aggregate supply and demand of the non-tradable good generates additional welfare gains from immigration.

The second chapter revisits the effect of brain drain on inequality and development in sub-Saharan African countries. The study suggest that accounting for large informal sector in the region and allowing for search frictions in labour market lead to ambiguous theoretical effects of brain drain on inequality and development. Therefore, it conducts a detailed quantitative analysis to estimate the effects of brain drain on development and inequality in Sub-Saharan Africa. The study concludes that brain drain induces income losses in low-skilled workers and increase inequality between high-skilled and low-skilled workers. The size of income loss depends on the technological gap between formal and informal sector as well as on education technology in a country.

The last chapter quantifies the effect of fertility norms on the education of the children in Pakistan. It shows that when the mothers are exposed to higher fertility norms they are forced to choose higher fertility to be compatible with the rest of the society, this adversely affects the quality of the children. The study shows that childlessness in Pakistan is prevented in women with high opportunity cost by high fertility norms. It proposes that fertility norms govern the response of fertility behaviour in women to changes in economic development. In other words opportunity cost effect of wage does not operate efficiently in presence of high fertility norms in the society. The study also concludes that less educated women benefit more in terms of investment in education of children from improvement in economic (wage) and social development, where social development implies lower fertility norms.

Chapter 6

Appendix

6.1 Appendix to chapter 02

Proof for the Nash Bargaining Solution

The first order condition of the Nash bargaining problem for properly matched workers is given by:

$$\beta_j^i(1-t)(J_{jn}^i - V_j^i) = (1-\beta_j^i)P(W_{jn}^i - U_{jn}^i) \qquad i = L, H$$

First, we focus on low skill workers with the present value of unemployment rU_{jn}^L. Inserting rU_{jn}^L into the equation for $W_{jn}^L - U_{jn}^L$ we get:

$$W_{jn}^L - U_{jn}^L = \frac{[w_{jn}^L(1-t) - b_{jn}^L]/P}{r+\delta+h_{jn}^L\lambda(\theta_j^L)} \quad \Rightarrow \quad \beta_j^L(1-t)\frac{p_j y_{jn}^L - w_{jn}^L - rV_j^L}{r+\delta} = (1-\beta_j^L)\frac{(w_{jn}^L(1-t) - b_{jn}^L)}{r+\delta+h_{jn}^L\lambda(\theta_j^L)}$$

Rewriting this equation and expressing w_{jn}^L gives us the final equation:

$$w_{jn}^L = \frac{\beta_j^L(p_j y_{jn}^L - rV_j^L)(r+\delta+h_{jn}^L\lambda(\theta_j^L)) + (1-\beta_j^L)(r+\delta)b_{jn}^L/(1-t)}{r+\delta+\beta_j^L h_{jn}^L\lambda(\theta_j^L)}$$

Second, consider properly matched high skill workers with a present value of unemployment rU_{jn}^H:

$$\begin{aligned}(r+\delta)(W_{jn}^H - U_{jn}^H) &= \frac{w_{jn}^H(1-t)+T}{P} - rU_{jn}^H \\ &= \frac{w_{jn}^H(1-t) - b_{jn}^H}{P} - h_{jn}^M\lambda(\theta_j^L)(W_{jn}^M - U_{jn}^H) - h_{jn}^H\lambda(\theta_j^H)(W_{jn}^H - U_{jn}^H)\end{aligned}$$

$$(r+\delta+h_{jn}^H\lambda(\theta_j^H))(W_{jn}^H - U_{jn}^H) = \frac{w_{jn}^H(1-t) - b_{jn}^H}{P} - h_{jn}^M\lambda(\theta_j^L)\frac{w_{jn}^M(1-t) - b_{jn}^H}{P(r+\delta+h_{jn}^H\lambda(\theta_j^H) + h_{jn}^M\lambda(\theta_j^L))}$$

where $(W_{jn}^M - U_{jn}^H$ is derived below. The first order condition for w_{jn}^H is then:

$$\beta_j^H(1-t)\frac{p_j y_{jn}^H - w_{jn}^H - rV_j^H}{r+\delta} = (1-\beta_j^H)\Big(\frac{w_{jn}^H(1-t) - b_{jn}^H - h_{jn}^M\lambda(\theta_j^L)\frac{w_{jn}^M(1-t)-b_{jn}^H}{(r+\delta+h_{jn}^H\lambda(\theta_j^H)+h_{jn}^M\lambda(\theta_j^L))}}{r+\delta+h_{jn}^H\lambda(\theta_j^H)}\Big)$$

so the equilibrium equation for the wage w_{jn}^H is:

$$w_{jn}^H = \frac{\beta_j^H(p_j y_{jn}^H - rV_j^H)(r+\delta+h_{jn}^H\lambda(\theta_j^H)) + (1-\beta_j^H)\frac{[b_{jn}^H(r+\delta+h_{jn}^H\lambda(\theta_j^H))+h_{jn}^M\lambda(\theta_j^L)w_{jn}^M(1-t)](r+\delta)/(1-t)}{r+\delta+h_{jn}^H\lambda(\theta_j^H)+h_{jn}^M\lambda(\theta_j^L)}}{r+\delta+h_{jn}^H\lambda(\theta_j^H)\beta_j^H}$$

Next consider mismatched high skill workers, bargaining over the wage w_{jn}^M. The first order condition is:

$$(1-\beta_j^L)P(W_{jn}^M - U_{jn}^H) = \beta_j^L(1-t)(J_{jn}^M - V_{jn}^L)$$

$$\begin{aligned}(r+\delta)(W_{jn}^M - U_{jn}^H) &= \frac{w_{jn}^M(1-t)+T}{P} + h_{jn}^H\lambda(\theta_j^H)(W_{jn}^H - W_{jn}^M) - rU_{jn}^H \\ &= \frac{w_{jn}^M(1-t)}{P} + h_{jn}^H\lambda(\theta_j^H)(U_{jn}^H - W_{jn}^M) - \frac{b_{jn}^H}{P} - h_{jn}^M\lambda(\theta_j^L)(W_{jn}^M - U_{jn}^H)\end{aligned}$$

$$W_{jn}^M - U_{jn}^H = \frac{w_{jn}^M(1-t) - b_{jn}^H}{P(r+\delta+h_{jn}^H\lambda(\theta_j^H)+h_{jn}^M\lambda(\theta_j^L))}$$

so the first order condition becomes:

$$\beta_j^L(1-t)\frac{p_j y_{jn}^M - w_{jn}^M - rV_j^L}{r+\delta+h_{jn}^H\lambda(\theta_j^H)} = (1-\beta_j^L)\frac{w_{jn}^M(1-t) - b_{jn}^H}{r+\delta+h_{jn}^H\lambda(\theta_j^H)+h_{jn}^M\lambda(\theta_j^L)}$$

Rewriting this equation and expressing w_{jn}^M gives us the final equation:

$$w_{jn}^M = \frac{\beta_j^L(p_j y_{jn}^M - rV_j^L)[r+\delta+h_{jn}^H\lambda(\theta_j^H)+h_{jn}^M\lambda(\theta_j^L)] + (1-\beta_j^L)b_{jn}^H[r+\delta+h_{jn}^H\lambda(\theta_j^H)]/(1-t)}{r+\delta+h_{jn}^H\lambda(\theta_j^H)+h_{jn}^M\lambda(\theta_j^L)\beta_j^L}$$

Definition of variables and data description

Our definition of the immigrant status is based on variables *bbp*140 (German nationality) and *bbp*14201 (German nationality since birth). Only if both variables take value 1 we classify the individual as a native. Otherwise the person is assigned an immigrant status. Thus our definition of immigrants includes individuals with foreign citizenship and those who changed their citizenship for the German one at some later stage in their life. The definition of occupational mismatch is based on variables *bbp*29 and *bbp*30. The definition of unemployment is based on variable *bbp*06 (Registered unemployed). Our definition of employment is based on variable *bbp*09. Thus workers are classified as employed if they are full-time employed or regularly part-time employed. The skill level of workers is based on variable *bbbilzeit*, which takes values between 7 and 18. Low skill workers are those with schooling less or equal to 12 years, workers with more schooling years are classified as high skilled. The sector of production is based on variable $e1110611$. Sector 1 includes Agriculture, Energy, Mining, Manufacturing, Construction and Trade, whereas Sector 2 includes Transportation, Banking, Insurance and Other services. Sector information for unemployed workers is recovered from their jobs in the previous 5 years (2006-2010) based on variables $e1110606$, $e1110607$, $e1110608$, $e1110609$, $e1110610$. The information can be easily extracted from German Socio Economic Panel. The questionnaire to the survey provides further details on the variables.

Table A1. Regression outputs: coefficients and marginal effects

	(1)	(2)	(3)	(4)	(5)
	Mismatch, probit		Unemployment, probit		LNwage, OLS
	Coefficient	% change	Coefficient	% change	Coef.=% change
Native	-0.455***	-0.090	-0.126*	-0.013	0.069***
	(0.101)	(0.020)	(0.067)	(0.007)	(0.021)
Sector2(Services)	-0.502***	-0.099	-0.041	-0.004	0.022
	(0.060)	(0.012)	(0.045)	(0.004)	(0.012)
Male	-0.401***	-0.079	-0.126***	-0.013	0.478***
	(0.059)	(0.012)	(0.044)	(0.004)	(0.012)
Age	0.054***	0.011	-0.071***	-0.007	0.046***
	(0.020)	(0.004)	(0.012)	(0.001)	(0.004)
$Age^2/1000$	-0.531**		0.835***		-0.509***
	(0.226)		(0.131)		(0.043)
High education			-0.515***	-0.051	0.500***
			(0.052)	(0.005)	(0.013)
High education ∗ Mismatch					-0.430***
					(0.027)
Tenure					0.012***
					(0.001)
West	-0.084	-0.017			0.179***
	(0.067)	(0.013)			(0.014)
$5 <$ *Firm size* ≤ 10	-0.149	-0.035			0.058*
	(0.136)	(0.031)			(0.028)
$10 <$ *Firm size* ≤ 20	-0.204	-0.046			0.077**
	(0.139)	(0.031)			(0.028)
$20 <$ *Firm size* ≤ 100	-0.141	-0.033			0.184***
	(0.109)	(0.026)			(0.023)
$100 <$ *Firm size* ≤ 200	-0.171	-0.040			0.216***
	(0.127)	(0.029)			(0.027)
$200 <$ *Firm size* ≤ 2000	-0.234**	0.052			0.266***
	(0.109)	(0.026)			(0.023)
$2000 <$ *Firm size*	-0.416***	-0.085			0.317***
	(0.106)	(0.024)			(0.023)
Constant	-1.209***		0.107		5.82***
	(0.462)		(0.262)		(0.087)
Observations	3431		10257		7835
(Pseudo) R^2	0.060		0.041		0.412

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A2 25% increase in low skill immigration in the benchmark model. This table shows absolute changes of endogenous variables with the initial levels of each variable given in the first row as well as relative (%) changes in welfare

	w^L_{1I}	w^L_{1N}	w^H_{1I}	w^M_{1I}	w^H_{1N}	w^M_{1N}	w^L_{2I}	w^L_{2N}	w^H_{2I}	w^M_{2I}	w^H_{2N}	w^M_{2N}
	0.3684	0.3800	0.6329	0.3016	0.6398	0.3548	0.3119	0.3580	0.5513	0.3361	0.6081	0.3529
$u\|y,v,p$	-0.0008	-0.0007	+0.0000	+0.0001	+0.0000	+0.0000	-0.0006	-0.0006	-0.0000	-0.0001	+0.0000	+0.0000
$u,y\|v,p$	-0.0083	-0.0086	+0.0303	-0.0072	+0.0312	-0.0076	-0.0103	-0.0111	+0.0111	-0.0095	+0.0128	-0.0088
$u,y,v\|p$	-0.0054	-0.0055	+0.0200	-0.0045	+0.0203	-0.0048	-0.0068	-0.0075	+0.0075	-0.0061	+0.0085	-0.0053
u,y,v,p	–	–	–	–	–	–	+0.0297	+0.0318	+0.0575	+0.0252	+0.0609	+0.0232

	u^L_{1I}	u^L_{1N}	u^H_{1I}	m^H_{1I}	u^H_{1N}	m^H_{1N}	u^L_{2I}	u^L_{2N}	u^H_{2I}	m^H_{2I}	u^H_{2N}	m^H_{2N}
	0.0826	0.0663	0.0276	0.2969	0.0222	0.1785	0.0793	0.0659	0.0283	0.1792	0.0213	0.0932
$u\|y,v,p$	+0.0040	+0.0033	+0.0013	-0.0013	+0.0011	-0.0011	+0.0019	+0.0016	+0.0006	-0.0005	+0.0005	-0.0006
$u,y\|v,p$	–	–	–	–	–	–	–	–	–	–	–	–
$u,y,v\|p$	+0.0017	+0.0014	+0.0005	-0.0117	+0.0003	-0.0085	+0.0026	+0.0022	+0.0008	-0.0055	+0.0005	-0.0034
u,y,v,p	–	–	–	–	–	–	-0.0099	-0.0083	-0.0035	-0.0109	-0.0026	-0.0063

	Σ^L_{1I}	Σ^L_{1N}	Σ^H_{1I}	Σ^H_{1N}	Σ^L_{2I}	Σ^L_{2N}	Σ^H_{2I}	Σ^H_{2N}
	0.0984	0.1008	0.1273	0.1369	0.0892	0.0971	0.1239	0.1363
$u,y,v,p\|T$	-0.0033	-0.0034	-0.0004	-0.0004	+0.0026	+0.0028	+0.0059	+0.0064
% change	-3.32%	-3.33%	-0.33%	-0.27%	+2.92%	+2.87%	+4.78%	+4.72%
u,y,v,p,T	-0.0012	-0.0013	+0.0017	+0.0017	+0.0047	+0.0049	+0.0080	+0.0085
% change	-1.19%	-1.25%	+1.32%	+1.27%	+5.28%	+5.04%	+6.48%	+6.26%

Table A3. 25% increase in low skill immigration in the model with competitive labour market

	w^L_{1I}	w^L_{1N}	w^H_{1I}	w^M_{1I}	w^H_{1N}	w^M_{1N}	w^L_{2I}	w^L_{2N}	w^H_{2I}	w^M_{2I}	w^H_{2N}	w^M_{2N}
	0.3684	0.3800	0.6329	0.3016	0.6398	0.3548	0.3119	0.3580	0.5513	0.3361	0.6081	0.3529
u, y, v, p	-0.0048	-0.0049	+0.0175	-0.0039	+0.0177	-0.0046	+0.0154	+0.0177	+0.0400	+0.0166	+0.0442	+0.0174

	Σ^L_{1I}	Σ^L_{1N}	Σ^H_{1I}	Σ^H_{1N}	Σ^L_{2I}	Σ^L_{2N}	Σ^H_{2I}	Σ^H_{2N}
	0.2271	0.2325	0.2937	0.3160	0.2058	0.2241	0.2859	0.3145
$u, y, v, p\|T$	-0.0095	-0.0098	-0.0061	-0.0058	-0.0017	-0.0015	+0.0033	+0.0046
% change	-4.18%	-4.20%	-2.07%	-1.85%	-0.83%	-0.65%	+1.16%	+1.47%
u, y, v, p, T	-0.0069	-0.0072	-0.0035	-0.0032	+0.0009	+0.0011	+0.0059	+0.0072
% change	-3.04%	-3.09%	-1.19%	-1.03%	+0.42%	+0.50%	+2.07%	+2.29%

Table A4. 25% increase in low skill immigration in the model with endogenous unemployment benefits. This table shows absolute changes of endogenous variables with the initial levels of each variable given in the first row as well as relative (%) changes in welfare

	w^L_{1I}	w^L_{1N}	w^H_{1I}	w^M_{1I}	w^H_{1N}	w^M_{1N}	w^L_{2I}	w^L_{2N}	w^H_{2I}	w^M_{2I}	w^H_{2N}	w^M_{2N}
	0.3684	0.3800	0.6329	0.3016	0.6398	0.3548	0.3119	0.3580	0.5513	0.3361	0.6081	0.3529
u, y, v, p	-0.0059	-0.0061	+0.0211	-0.0036	+0.0215	-0.0035	+0.0419	+0.0444	+0.0716	+0.0437	+0.0755	+0.0447

	u^L_{1I}	u^L_{1N}	u^H_{1I}	m^H_{1I}	u^H_{1N}	m^H_{1N}	u^L_{2I}	u^L_{2N}	u^H_{2I}	m^H_{2I}	u^H_{2N}	m^H_{2N}
	0.0826	0.0663	0.0276	0.2969	0.0222	0.1785	0.0793	0.0659	0.0283	0.1792	0.0213	0.0932
u, y, v, p	+0.0010	+0.0009	+0.0003	-0.0109	+0.0002	-0.0079	-0.0049	-0.0042	-0.0018	-0.0091	-0.0014	-0.0053

	Σ^L_{1I}	Σ^L_{1N}	Σ^H_{1I}	Σ^H_{1N}	Σ^L_{2I}	Σ^L_{2N}	Σ^H_{2I}	Σ^H_{2N}
	0.0984	0.1008	0.1273	0.1369	0.0892	0.0971	0.1239	0.1363
$u, y, v, p \mid T$	-0.0040	-0.0041	-0.0011	+0.0003	+0.0041	+0.0042	+0.0074	0.0079
% change	-4.07%	-4.07%	-0.86%	+0.22%	+4.60%	+4.33%	+5.97%	+5.80%
u, y, v, p, T	-0.0015	-0.0016	+0.0014	+0.0028	+0.0066	+0.0068	+0.0099	+0.0105
% change	-1.52%	+1.59%	+1.10%	+2.05%	+7.39%	+7.00%	+7.99%	+7.70%

Table A5. 25% increase in low skill immigration under CES. This table shows absolute changes of endogenous variables with the initial levels of each variable given in the first row as well as relative (%) changes in welfare

	w^L_{1I}	w^L_{1N}	w^H_{1I}	w^M_{1I}	w^H_{1N}	w^M_{1N}	w^L_{2I}	w^L_{2N}	w^H_{2I}	w^M_{2I}	w^H_{2N}	w^M_{2N}
	0.3684	0.3800	0.6329	0.3016	0.6398	0.3548	0.3119	0.3580	0.5513	0.3361	0.6081	0.3529
u, y, v, p	-0.0024	-0.0024	+0.0089	-0.0019	+0.0091	-0.0021	+0.0339	+0.0363	+0.0529	+0.0291	+0.0557	+0.0266

	u^L_{1I}	u^L_{1N}	u^H_{1I}	m^H_{1I}	u^H_{1N}	m^H_{1N}	u^L_{2I}	u^L_{2N}	u^H_{2I}	m^H_{2I}	u^H_{2N}	m^H_{2N}
	0.0826	0.0663	0.0276	0.2969	0.0222	0.1785	0.0793	0.0659	0.0283	0.1792	0.0213	0.0932
u, y, v, p	+0.0006	+0.0005	+0.0002	-0.0053	+0.0001	-0.0039	-0.0109	-0.0092	-0.0039	-0.0079	-0.0029	-0.0044

	Σ^L_{1I}	Σ^L_{1N}	Σ^H_{1I}	Σ^H_{1N}	Σ^L_{2I}	Σ^L_{2N}	Σ^H_{2I}	Σ^H_{2N}
	0.0949	0.0972	0.1228	0.1321	0.0860	0.0937	0.1195	0.1315
$u, y, v, p\|T$	-0.0027	-0.0028	-0.0018	-0.0019	+0.0032	+0.0034	+0.0051	+0.0054
% change	-2.85%	-2.88%	-1.47%	-1.44%	+3.72%	+3.63%	+4.27%	+4.11%
u, y, v, p, T	-0.0006	-0.0007	+0.0002	+0.0001	+0.0052	+0.0055	+0.0072	+0.0075
% change	-0.63%	-0.72%	+0.16%	+0.08%	+6.05%	+5.87%	+6.03%	+5.70%

Table A6. Overview of all parameter values

Parameter value			Parameter explanation and source
	$i=L$	$i=H$	
r	0.01		Annual discount rate equal to 4% (assumption)
δ	0.02		Average tenure of employees equal to 12.25 years (GSOEP)
λ_0	0.5801		Average vacancy duration $63.7/92 = 0.69$ quarters (BA data)
η	0.4607		Slope from the regression of $\ln q(\theta_t)$ on $\ln \theta_t$ (BA data)
t	0.35		1-ratio between the net (1619 EUR) and gross salary (2505 EUR)
z	0.612		Net unemployment benefit replacement rate in 2011 (OECD.Stat)
χ_1	0.7306		From equation (2.24) and wage $w_{1I}^H = 0.6329$ (via $p_1 y_{1I}^H$)
χ_2	0.4699		From equation (2.24) and wage $w_{2I}^H = 0.5513$ (via $p_1 y_{2I}^H$)
p_1	1.5939		From equation (2.24) and normalisation $p_1 y_{2I}^L = 1$
σ	0.3		Elasticity of substitution from Ngai and Pissarides (2004).
a_1	0.3286		From $C_2 = Y_2$ and $p_2 Y_2/(p_1 Y_1 + p_2 Y_2) = 0.6112$
rK_1	0.4358		Free-entry condition (2.8) for V_1^L
rK_2	0.6568		Free-entry condition (2.8) for V_2^L
h_{1I}^i	0.7888	0.5228	Unemployment of immigrants $\frac{u_{1I}^L}{g_{1I}^L} = 0.0826$ and $\frac{u_{1I}^H}{g_{1I}^H} = 0.0276$ (GSOEP)
h_{1I}^M	–	2.3533	Mismatch of high skill immigrants $\frac{m_{1I}^H}{g_{1I}^H} = 0.2969$ (GSOEP)
h_{1N}^M	–	2.8394	Mismatch of high skill natives $\frac{m_{1N}^H}{g_{1N}^H} = 0.1784$ (GSOEP)
h_{2I}^i	0.8188	0.4939	Unemployment of immigrants $\frac{u_{2I}^L}{g_{2I}^L} = 0.0793$ and $\frac{u_{2I}^H}{g_{2I}^H} = 0.0283$ (GSOEP)
h_{2I}^M	–	2.1543	Mismatch of high skill immigrants $\frac{m_{2I}^H}{g_{2I}^H} = 0.1792$ (GSOEP)
h_{2N}^M	–	2.6929	Mismatch of high skill natives $\frac{m_{2N}^H}{g_{2N}^H} = 0.0932$ (GSOEP)
β_1^i	0.4566	0.8364	Gross wage income/output=0.49 in Sector 1 (DESTATIS 2011)
β_2^i	0.3073	0.6462	Gross wage income/output=0.41 in Sector 2 (DESTATIS 2011)
γ_1^i	0.0984	1.1545	From $\frac{\gamma_1^L}{\overline{q}(\theta_1^L)} = 0.0790$ and $\frac{\gamma_1^H}{\overline{q}(\theta_1^H)} = 0.3874$, Rebien et al. (2017)
γ_2^i	0.1195	0.6602	From $\frac{\gamma_2^L}{\overline{q}(\theta_2^L)} = 0.0790$ and $\frac{\gamma_2^H}{\overline{q}(\theta_2^H)} = 0.3874$, Rebien et al. (2017)
ψ_{1N}^k	1.0101	0.9956	From (2.25), $w_{1N}^L = 0.3800$ and $w_{1N}^H = 0.6398$ (via $p_1 y_{1N}^L$ and $p_1 y_{1N}^H$)
ψ_{2N}^k	1.0448	1.0367	From (2.25), $w_{2N}^L = 0.3580$ and $w_{2N}^H = 0.6081$ (via $p_2 y_{2N}^L$ and $p_2 y_{2N}^H$)
ψ_{1N}^M	–	0.9582	From (2.26), $w_{1N}^M = 0.3548$ (via $p_1 y_{1N}^M$)
ψ_{2N}^M	–	1.0079	From (2.26), $w_{2N}^M = 0.3529$ (via $p_2 y_{2N}^M$)
ψ_{1I}^M	–	0.8912	From (2.26), $w_{1I}^M = 0.3016$(via $p_1 y_{1I}^M$)
ψ_{2I}^M	–	1.0006	From (2.26), $w_{2I}^M = 0.3361$ (via $p_2 y_{2I}^M$)

6.2 Appendix to chapter 03

Table B1. Descriptive stats

Variable	Mean	St. dev.	Min	Max
Pop. growth differential	0.0531	0.0117	0,0205	0.0770
Informality rate	0.5423	0.1463	0.3390	0.8000
Informal Activities (as percentage of official GNP)	0.2538	0.0815	0.1540	0.4880
Official GDP per worker in PPP	3592.99	4939.64	459.19	24781.91
Proportion of college-educated (as % of labor force)	0.0218	0.0146	0.0040	0.0594
Brain drain (as % of college-educated labor force)	0.1790	0.1594	0.0256	0.6784
Share of low-skilled in informality	0.5480	0.1466	0.3481	0.8053
Share of high-skilled in informality	0.2740	0.0733	0.1740	0.4026

Table B2. Parameters with country-specific variations

Country	ISO	A_F	α	ψ	p	ρ	g	μ_L	μ_H
Angola	AGO	2112.7	0.437	0.091	1.98E-04	1.06E-04	5.35E-03	0.176	0.324
Benin	BEN	2854.0	0.445	0.032	3.88E-04	3.94E-05	4.43E-03	0.041	0.127
Bostwana	BWA	9939.5	0.369	0.061	1.28E-04	4.46E-05	2.44E-03	0.121	0.237
Burkina Faso	BFA	1488.6	0.437	0.049	1.29E-04	4.30E-05	4.99E-03	0.064	0.159
Cameroon	CMR	2166.2	0.502	0.052	7.47E-04	4.83E-05	4.28E-03	0.069	0.168
Chad	TCD	328.1	0.768	0.191	5.16E-04	1.35E-05	5.61E-03	0.161	0.313
Congo, Dem Rep	COD	639.4	0.495	0.027	6.15E-04	2.97E-05	4.09E-03	0.036	0.119
Congo, Rep	COG	3765.1	0.361	0.057	1.54E-03	1.69E-04	5.40E-03	0.104	0.215
Cote d'Ivoire	CIV	1966.4	0.466	0.053	2.75E-04	7.20E-05	4.42E-03	0.071	0.172
Ethiopia	ETH	661.1	0.492	0.054	4.49E-04	4.57E-05	4.52E-03	0.071	0.171
Gabon	GAB	11810.2	0.567	0.087	5.04E-04	4.95E-05	3.42E-03	0.079	0.182
Gambia	GMB	1633.8	0.685	0.053	3.21E-03	2.02E-05	4.68E-03	0.037	0.120
Ghana	GHA	1226.4	0.631	0.059	1.61E-03	3.35E-05	3.56E-03	0.048	0.137
Guinea	GIN	2295.9	0.400	0.028	2.15E-04	4.56E-05	4.57E-03	0.038	0.122
Kenya	KEN	985.1	0.534	0.108	1.53E-03	3.85E-05	3.92E-03	0.146	0.275
Lesotho	LSO	723.4	0.596	0.099	1.20E-04	1.30E-05	2.88E-03	0.145	0.287
Liberia	LBR	345.5	0.479	0.104	1.95E-03	9.40E-05	4.36E-03	0.183	0.328
Madagascar	MDG	1193.7	0.429	0.059	3.15E-04	5.01E-05	4.04E-03	0.081	0.183
Malawi	MWI	519.5	0.633	0.098	1.00E-03	1.55E-05	4.75E-03	0.097	0.211
Mali	MLI	472.7	0.637	0.137	8.09E-04	1.86E-05	5.41E-03	0.173	0.325
Mauritania	MRT	1285.9	0.484	0.093	3.57E-04	3.94E-05	4.10E-03	0.145	0.274
Namibia	NAM	4590.1	0.403	0.066	1.02E-04	5.31E-05	2.99E-03	0.112	0.227
Niger	NER	472.5	0.625	0.105	3.41E-04	1.40E-05	6.16E-03	0.103	0.219
Nigeria	NGA	1612.1	0.407	0.140	5.08E-04	7.59E-05	4.80E-03	0.158	0.230
Rwanda	RWA	936.9	0.643	0.059	1.30E-03	1.40E-05	4.07E-03	0.045	0.131
Senegal	SEN	1911.9	0.480	0.055	7.36E-04	5.19E-05	4.24E-03	0.068	0.165
Sierra Leone	SLE	525.8	0.587	0.046	2.28E-03	4.04E-05	4.60E-03	0.052	0.143
Sudan	SDN	1082.6	0.493	0.071	2.78E-04	3.70E-05	4.03E-03	0.128	0.260
Tanzania	TZA	775.6	0.483	0.093	5.50E-04	4.63E-05	4.50E-03	0.140	0.266
Togo	TGO	757.3	0.427	0.067	6.90E-04	4.84E-05	4.14E-03	0.150	0.288
Tunisia	TUN	5705.0	0.357	0.047	2.14E-04	5.36E-05	1.65E-03	0.077	0.175
Uganda	UGA	817.4	0.571	0.083	1.90E-03	3.57E-05	5.23E-03	0.085	0.191
Zimbabwe	ZWE	213.8	0.372	0.083	4.30E-04	9.22E-05	3.25E-03	0.191	0.331
Mean	-	2055.0	0.506	0.076	7.86E-04	4.82E-05	4.27E-03	0.103	0.214
St. Dev.	-	2600.3	0.104	0.035	7.38E-04	3.17E-05	9.36E-04	0.048	0.069
Coeff. Var.	-	1.265	0.206	0.460	0.939	0.657	0.219	0.469	0.321

Table B3. Correlation between country-specific parameters

	A_F	α	A_I/A_F	p	ρ	g	μ_L	μ_H
A_F	1.000	-0.312	-0.191	-0.235	0.172	0.495	-0.148	-0.160
α	-	1.000	0.446	0.446	-0.655	0.382	-0.100	-0.034
A_I/A_F	-	-	1.000	-0.042	-0.124	0.332	0.739	0.721
p	-	-	-	1.000	0.001	0.237	-0.209	-0.209
ρ	-	-	-	-	1.000	0.048	0.274	0.221
g	-	-	-	-	-	1.000	0.056	0.063
μ_L	-	-	-	-	-	-	1.000	0.984
μ_H	-	-	-	-	-	-	-	1.000

Table B4. Decomposition of $\mathbf{\Delta \overline{w}_L / \overline{w}_L}$

Country	R	R^A	R/R^A	$R-R^A$	$R-R^Z$	$R-R^M$	$R-R^T$
Angola	-1.0%	-0.9%	1.148	-0.1%	-0.1%	-0.1%	-0.3%
Benin	-2.0%	-1.6%	1.234	-0.4%	0.1%	-0.1%	-1.2%
Bostwana	-1.7%	-0.6%	2.818	-1.1%	-0.9%	0.0%	-1.6%
Burkina Faso	-0.6%	-0.6%	0.973	0.0%	0.1%	0.0%	-0.1%
Cameroon	-3.0%	-2.8%	1.073	-0.2%	-0.2%	0.0%	-0.9%
Chad	-0.2%	-2.1%	0.120	1.8%	0.3%	0.0%	0.7%
Congo, Dem Rep	-2.8%	-2.4%	1.157	-0.4%	0.2%	-0.3%	0.8%
Congo, Rep	-8.2%	-4.6%	1.786	-3.6%	-2.0%	0.0%	-5.1%
Cote d'Ivoire	-1.6%	-1.2%	1.335	-0.4%	-0.2%	0.0%	-0.4%
Ethiopia	-1.8%	-1.8%	0.995	0.0%	0.1%	0.0%	0.3%
Gabon	-2.1%	-2.0%	1.060	-0.1%	-0.6%	0.0%	-2.3%
Gambia	-2.7%	-7.0%	0.390	4.2%	1.2%	-0.3%	-0.1%
Ghana	-3.6%	-4.8%	0.754	1.2%	-0.3%	-0.2%	1.2%
Guinea	-1.3%	-1.0%	1.394	-0.4%	0.1%	0.0%	-0.6%
Kenya	-3.7%	-4.6%	0.799	0.9%	-0.2%	-0.1%	0.7%
Lesotho	-0.4%	-0.6%	0.667	0.2%	0.0%	0.0%	0.2%
Liberia	-6.6%	-5.3%	1.231	-1.2%	-1.7%	-0.4%	0.6%
Madagascar	-1.8%	-1.4%	1.329	-0.4%	-0.2%	0.0%	-0.2%
Malawi	-1.1%	-3.4%	0.326	2.3%	0.8%	0.0%	1.1%
Mali	-0.8%	-2.9%	0.273	2.1%	0.7%	0.0%	0.8%
Mauritania	-1.4%	-1.5%	0.938	0.1%	0.0%	0.0%	-0.1%
Namibia	-1.0%	-0.5%	2.150	-0.5%	-0.4%	0.0%	-0.8%
Niger	-0.3%	-1.5%	0.220	1.1%	0.5%	0.0%	0.3%
Nigeria	-1.9%	-2.0%	0.934	0.1%	-0.2%	-0.3%	-0.4%
Rwanda	-1.8%	-4.1%	0.424	2.4%	0.8%	-0.1%	1.3%
Senegal	-3.2%	-2.7%	1.160	-0.4%	-0.3%	0.0%	-0.9%
Sierra Leone	-4.5%	-5.8%	0.762	1.4%	0.4%	-0.3%	3.2%
Sudan	-1.2%	-1.2%	0.976	0.0%	0.0%	0.0%	0.1%
Tanzania	-1.9%	-2.2%	0.890	0.2%	0.0%	-0.1%	0.2%
Togo	-3.2%	-2.6%	1.241	-0.6%	-0.3%	-0.1%	-0.3%
Tunisia	-4.8%	-1.0%	5.069	-3.9%	-3.5%	0.1%	-3.9%
Uganda	-2.9%	-5.3%	0.547	2.4%	0.9%	0.0%	1.3%
Zimbabwe	-4.2%	-1.8%	2.358	-2.4%	-2.0%	-0.4%	-0.9%

6.3 Appendix to chapter 04

Table C1. Probability of childlessness with the level of Norms

Education Norms	Ethnicity Norms	Probability of childlessness
4.66	6.72	0.069
4.66	6.62	0.070
4.66	6.94	0.069
4.66	7.05	0.068
4.66	6.78	0.069
4.66	7.54	0.069
4.66	7.18	0.068
4.66	6.63	0.070
6.09	6.72	0.044
6.09	6.62	0.044
6.09	6.94	0.044
6.09	7.05	0.044
6.09	6.78	0.044
6.09	7.54	0.046
6.09	7.18	0.044
6.09	6.63	0.044
6.70	6.72	0.036
6.70	6.62	0.036
6.70	6.94	0.036
6.70	7.05	0.037
6.70	6.78	0.036
6.70	7.54	0.039
6.70	7.18	0.037
6.70	6.63	0.036
6.94	6.72	0.033
6.94	6.62	0.033
6.94	6.94	0.034
6.94	7.05	0.034
6.94	6.78	0.033
6.94	7.54	0.036
6.94	7.18	0.035
6.94	6.63	0.033

Table C2. Probability of childlessness with the years of schooling

Years of schooling	Probability of childlessness
0	0.127
1	0.124
2	0.122
3	0.121
4	0.120
5	0.119
6	0.118
7	0.118
8	0.119
9	0.119
10	0.120
11	0.121
12	0.122
13	0.124
14	0.126
15	0.128
16	0.130

Table C3. Robustness with completed fertility

Percentage change in expected count for those not always 0			
Variable	Percentage coefficient	Expected log count coefficient	S.E
Years of schooling	-2.8[a]	-0.029	0.006
Education Norm	10.2[b]	0.097	0.044
Ethnicity Norm	16.7[a]	0.154	0.047
Assets	-1.7	-0.018	0.026
Stillbirth/Miscarriage/Abortion	4.6[b]	0.045	0.031
Pun	-5.1	-0.053	0.045
Si	2.3	0.023	0.041
KPK	-8.9[b]	-0.093	0.040
Poorer	1.2	0.011	0.031
Middle	-1.2	-0.012	.034
Richer	-4.9	-0.050	0.039
Richest	-11.4[a]	-0.120	0.046
Small city	1.1	0.011	0.037
Countryside	0.1	0.001	0.040
Constant	—	0.212	0.457
Percentage change in odds of always 0			
Education Norm	33.6.5	0.290	0.988
Ethnicity Norm	-22.3	-0.252	0.620
Years of schooling	-0.9	-0.009	0.123

Note: The sample has 2,118 married women of which 58 have zero children. For region fixed effects, wealth effects, assets effects and experience of a terminated pregnancy/still birth, dummy variables are used. The errors are robust and clustered over primary sampling unit. The reference category is poorest married woman from Balochistan who lives in a big city and has experienced no terminated pregnancy/stillbirth. (a: Significant at 99 percent confidence interval ,b: Significant at 95 percent confidence interval , c: Significant at 90 percent confidence interval)

Table C4. Robustness with age and education of spouse

Percentage change in expected count for those not always 0			
Variable	Percentage coefficient	Expected log count coefficient	S.E
Years of schooling	-1.6[a]	-0.016	0.004
Education of Spouse	-0.5[a]	-0.005	0.001
Education Norm	15.6[a]	0.145	0.030
Ethnicity Norm	23.3[a]	0.201	0.033
Age in years	24.4[a]	0.218	0.007
Square of Age in years	-0.3[a]	-0.003	0.000
Age of spouse in years	3.3[a]	0.033	.003
Square of Age of spouse in years	-0.0[a]	-0.0003	0.000
Assets	-1.1	-0.011	0.015
Stillbirth/Miscarriage/Abortion	2.6[b]	0.026	0.011
Pun	-2.2	-0.022	0.029
Si	-1.8	-0.018	0.027
KPK	-6.7[a]	-0.069	0.026
Poorer	-1.6	-0.016	0.018
Middle	-2.0	-0.021	0.021
Richer	-7.6[a]	-0.079	0.023
Richest	-13.9[a]	-0.150	0.028
Small city	-0.8	-0.008	0.023
Countryside	-4.0[c]	-0.040	0.024
Constant	——	-6.107[a]	0.349
Percentage change in odds of always 0			
Education Norm	12.9	0.122	1.642
Ethnicity Norm	27.5	0.242	0.318
Age in years	-32.2[a]	-0.389	0.089
Square of Age in years	0.5[a]	0.005	0.001
Years of schooling	-6.7	-0.069	0.131

Note: The sample has 10,884 married of which 1396 have zero children. For region fixed effects, wealth effects, assets effects and experience of a terminated pregnancy/still birth, dummy variables are used. The errors are robust and clustered over primary sampling unit. The reference category is poorest married woman from Balochistan who lives in a big city and has at no terminated pregnancy/stillbirth. (a: Significant at 99 percent confidence interval ,b: Significant at 95 percent confidence interval , c: Significant at 90 percent confidence interval)

Table C5. Robustness with age 20 and above at first birth

Percentage change in expected count for those not always 0			
Variable	Percentage coefficient	Expected log count coefficient	S.E
Years of schooling	-1.0^a	-0.011	0.004
Education Norm	14.6^a	0.136	0.027
Ethnicity Norm	25.4^a	0.226	0.047
Age in years	35.2^a	0.301	0.010
Square of Age in years	-0.3^a	-0.003	0.000
Assets	-1.3	-0.013	0.020
Stillbirth/Miscarriage/Abortion	0.9	0.009	0.014
Pun	-2.2	-0.022	0.034
Si	-3.8^b	-0.038	0.033
KPK	-8.7^a	-0.091	0.032
Poorer	-4.8^b	-0.049	0.025
Middle	-5.7^b	-0.059	0.028
Richer	-12.3^a	-0.132	0.030
Richest	-17.7^a	-0.195	0.036
Small city	-1.3	-0.030	0.028
Countryside	-1.3	-0.025	0.027
Constant	—	-7.319^a	0.430
Percentage change in odds of always 0			
Education Norm	10.2	0.097	0.660
Ethnicity Norm	82.5^b	0.601	0.287
Age in years	-57.7^a	-0.859	0.075
Square of Age in years	1.1^a	0.011	0.001
Years of schooling	-8.1	-0.085	0.062

Note: The sample has 3,981 married of which 693 have zero children. For region fixed effects, wealth effects, assets effects and experience of a terminated pregnancy/still birth, dummy variables are used. The errors are robust and clustered over primary sampling unit. The reference category is poorest married woman from Balochistan who lives in a big city and has at no terminated pregnancy/stillbirth. (a: Significant at 99 percent confidence interval ,b: Significant at 95 percent confidence interval , c: Significant at 90 percent confidence interval)

Proof C

Maximization problem

$$\begin{aligned}L_i = & \log[w_i(1-n_i\phi) - pe_i + R_i] + \theta\log[n_i - \pi N_i + a_1] + \lambda\log[e_i + a_2] + \nu_1(n_i - 0) \\ & + \nu_2(e_i - 0) + \nu_3(\frac{1}{\phi} - ni)\end{aligned} \tag{6.1}$$

Where ν_1, ν_2 and ν_3 are KT multipliers associated with $n_i \geq 0$, $e_i \geq 0$ and $n_i \leq 1/\phi$ respectively and $c_i = w_i(1-n_i\phi) - pe_i + R_i$.

First order conditions (focs) are as follows

$$\nu_1 - \nu_3 + \frac{\theta}{a_1 + n_i - N_i\pi} - \frac{w_i\phi}{R_i + pe_i + w(1-n_i\phi)} = 0 \tag{6.2}$$

$$\frac{\lambda}{a_2 + e_i} + \nu_2 + \frac{p}{R_i - pe_i + w_i(1-n_i\phi)} = 0 \tag{6.3}$$

$$n_i \geq 0, \quad \nu_1 \geq 0 \quad \text{and} \quad \nu_1 n_i = 0 \tag{6.4}$$

$$e_i \geq 0, \quad \nu_2 \geq 0 \quad \text{and} \quad \nu_2 e_i = 0 \tag{6.5}$$

$$n_i \leq \frac{1}{\phi}, \quad \nu_3 \geq 0 \quad \text{and} \quad \nu_3(\frac{1}{\phi} - n_i) = 0 \tag{6.6}$$

Interior regime solution

For the interior solution solving focs for n_i and e_i with $\nu_1 = \nu_2 = \nu_3 = 0$ yields (4.8) and (4.8). Using (4.8) and (4.9) in c_i gives following level of consumption in interior regime

$$c_i = \frac{a_2 p + R_i + w + w_i(a_1 - \pi N_i)\phi}{1 + \theta + \lambda} \tag{6.7}$$

Solving $n_i^* = 0$ for wage yields w_3 and gives the upper bound on wage for interior solution. Solving $e_i = 0$ for wage yields w_2 which is the minimum wage required to invest in education of children. Solving $n_i^* = \frac{1}{\phi}$ for wage gives w_1 as the lower bound on wage to avoid full specialization. If the wage is below w_2 the women will not educate their children if the wage goes below w_1 and w_2 the women will both fully specialize and not educate children as long as $R_i \leq \overline{R}$.

No education solution

For no education regime we must have $e_i = 0, \nu_1 = 0, \nu_3 = 0, \nu_2 > 0$. Under these conditions solving focs n_i yields $n^\star$ of (4.12) and

$$\nu_2 = \frac{a_2 p + a_2 p\theta - R_i\lambda - w_i\lambda - a_1 w_i\lambda\phi + N_i w_i\lambda\pi\phi}{a_2(R_i + w_i + a_1 w_i\phi - N_i w_i\pi\phi)} \tag{6.8}$$

To get the restrictions on wage for childlessness in this regime I first solve $n^\star = 0$ and get w_4 as the upper bound for childlessness. Remember that when KT multipliers are zero the related variable becomes positive and vice-versa. So, solving $\nu_2 = 0$ yields w_2 which is the minimum wage required to invest in education of children. Because if wage goes above this level ν_2 must be zero and e_i should be positive for optimal solution. So in this regime the individual must have a wage below $Min[w_4, w_2]$ so that she does not reach either to the opportunity driven childlessness level of wage or w_2 which enables her to invest in quality. To solve for the lower bound on wage I solve $n_i^\star = \frac{1}{\phi}$ which yields w_5, the wage below which individuals will fully specialize. Using $n^\star$ and $e_i = 0$ in c_i gives the consumption in no education regime as follows

$$ci = \frac{R_i + w + w_i(a_1 - \pi N_i)\phi}{1 + \theta} \tag{6.9}$$

Childlessness solution

Solving focs for $n_i = 0$, $e_i = 0$ and $\nu_3 = 0$ yields

$$\nu_1 = -\frac{R_i\theta + w_i(\theta - a_1\phi + N_i\pi\phi)}{(R_i + w_i)(a_1 - N_i\pi)} \quad \nu_2 = \frac{a_2 p - (R_i + w_i)\lambda}{a_2(R - i + w_i)} \tag{6.10}$$

Solving $\nu_1 = 0$ for w_i gives $w_i = w_3$. As soon as $\nu_1 = 0$, n_i will become positive. So, w_3 is the threshold for keeping $n_i = 0$ and $\nu_1 > 0$. Note that as soon as $n_i = 0$ quality by default takes the value zero. The same result is obtained when $n_i = 0$ in the "interior regime" is solved for w_i. Above w_3 women choose childlessness if they are in interior regime. Solving (4.12) by putting $n_i = 0$ for w_i gives $w_i = w_4$. This is the upper bound on wage for women in "no education regime". Women in "no education" regime choose childlessness above w_4 due to high opportunity cost. So, the over all restriction on childlessness takes the form as described in proposition in section 4.3. Consumption in this regime is simply $w_i + R_i$.

Full specialization without quality solution

In this regime individual fully specialize in child production and invest nothing in quality. It means $n_i = \frac{1}{\phi}$ while $e_i = 0$ which means $\nu_1 = 0, \nu_2 > 0, \nu_3 > 0$. I solve focs under these conditions which gives

$$\nu_2 = \frac{p}{R_i} - \frac{\lambda}{a_2} \quad \nu_3 = \frac{\phi(R_i\theta + w_i(-1 - a_1\phi + N_i\pi\phi))}{R_i(1 + a_1\phi - N_i\pi\phi)} \tag{6.11}$$

Solving $\nu_3 = 0$ for wage gives w_5 as the threshold on wage for full specialization. At this wage the women are indifferent between full specialization and no education while as soon as wage goes above this limit they strictly prefer "no education" regime and supply labour as well. When $\nu_2 = 0$ investment in quality is positive. Solving $\nu_2 = 0$ for R_i gives the threshold level for non-labour income $\overline{R}$ above this level individuals will move into "full specialization with quality" regime.

Full specialization with quality solution

Solving focs under condition $n_i = \frac{1}{\phi}, \nu_1 = 0, \nu_2 = 0, \nu_3 > 0$ yields eq (4.14) and the following

$$\nu_3 = \frac{\phi((a_2p + R_i)\theta - w_i(1+\lambda)(1 + a_1\phi - N_i\pi - \phi))}{(a_2p + R_i)(1 + a_1\phi - N_i\pi\phi)} \tag{6.12}$$

Solving (5.12) for wage gives w_1 that is the upper bound on wage for the women to stay in "full specialization" regime and not supply labour. Above w_1 the individual will enter into interior regime. Remember in this regime investment in education only depends on R_i and not w_i as regardless of wage the individual is rich enough to afford the education of child. So we have $\overline{R}$ as the required lower bound on non-labour income for an individual to be able to invest in education of children without worrying about wage. Putting $e_i = 0$ in (4.14) and solving for R_i gives , the same as obtained in "full specialization without quality" regime. At $\overline{R}$ women are indifferent between full specialization with or without quality. Consumption in this regime is given as follows

$$c_i = \frac{a_2p + R_i}{1+\lambda} \tag{6.13}$$

Table C6. Simulated fertility and quality of children across different ethnic groups

	Urdu		Punjabi		Sindhi		Pashtu		Balochistan		Saraiki		Baruhi		others	
Wage	Quantity	Quality	Quantity	Quality	Quantity	Quality	Quantity	Quality	Quantity	Quality	Quantity	Quality	Quantity	Quality	Quantity	Quality
1.000	5.52	1.65	5.49	1.68	5.61	1.59	5.64	1.56	5.55	1.63	5.69	1.52	5.82	1.42	5.49	1.67
1.005	5.40	1.80	5.37	1.83	5.48	1.74	5.52	1.71	5.42	1.79	5.57	1.67	5.70	1.56	5.37	1.83
1.011	5.36	1.90	5.32	1.92	5.44	1.84	5.48	1.81	5.38	1.88	5.53	1.77	5.66	1.67	5.33	1.93
1.017	5.31	1.99	5.28	2.02	5.39	1.93	5.43	1.91	5.33	1.98	5.48	1.87	5.61	1.77	5.28	2.02
1.023	5.27	2.09	5.23	2.12	5.35	2.03	5.39	2.00	5.29	2.08	5.44	1.97	5.57	1.86	5.24	2.12
1.028	5.22	2.19	5.19	2.21	5.30	2.13	5.34	2.10	5.25	2.17	5.39	2.06	5.52	1.96	5.19	2.21
1.031	5.01	2.38	4.97	2.41	5.09	2.32	5.13	2.29	5.03	2.37	5.17	2.26	5.31	2.16	4.97	2.41
1.034	5.12	2.43	4.95	2.46	5.07	2.37	5.11	2.34	5.01	2.41	5.15	2.31	5.28	2.20	4.95	2.46
1.037	4.96	2.48	4.93	2.51	5.04	2.42	5.08	2.39	4.99	2.47	5.13	2.35	5.26	2.26	4.93	2.50
1.039	4.94	2.53	4.90	2.55	5.02	2.47	5.06	2.44	4.97	2.51	5.11	2.40	5.24	2.30	4.91	2.55
1.043	4.91	2.57	4.88	2.60	4.99	2.52	5.04	2.48	4.94	2.56	5.09	2.45	5.22	2.35	4.89	2.60
1.046	4.90	2.62	4.86	2.65	4.98	2.56	5.02	2.54	4.92	2.61	5.06	2.50	5.20	2.40	4.86	2.61
1.049	4.88	2.67	4.84	2.70	4.96	2.61	4.99	2.58	4.90	2.67	5.04	2.55	5.17	2.45	4.84	2.70
1.088	4.14	3.63	4.10	3.66	4.22	3.57	4.26	3.55	4.16	3.62	4.31	3.50	4.44	3.41	4.10	3.66
1.128	3.87	4.26	3.83	4.28	3.95	4.20	3.99	4.17	3.89	4.24	4.04	4.13	4.17	4.04	3.84	4.28
1.171	3.61	4.87	3.57	4.90	3.69	4.81	3.73	4.79	3.63	4.86	3.78	4.75	3.91	4.66	3.58	4.90
1.215	3.36	5.48	3.32	5.51	3.44	5.43	3.48	5.40	3.38	5.47	3.53	5.36	3.66	5.27	3.31	5.50

Note: The values are calculated at ethnicity and education specific norms for each wage group. Quality is expenditure on education of children expressed as a percentage share relative to the expenditure on consumption.

Table C7. Simulated changes in quantity and quality of children across different ethnic and wage groups for norms set at replacement fertility rate of 2 children per woman

	Urdu		Punjabi		Sindhi		Pashtu		Balochistan		Saraiki		Baruhi		others	
Wage	Quantity	Quality	Quantity	Quality	Quantity	Quality	Quantity	Quality	Quantity	Quality	Quantity	Quality	Quantity	Quality	Quantity	Quality
1.000	-3.26	+2.33	-3.26	+2.30	-3.37	+2.39	-3.41	+2.41	-3.31	+2.34	-3.46	+2.45	-3.59	+2.55	-3.26	+2.30
1.005	-3.22	+2.26	-3.18	+2.23	-3.30	+2.33	-3.34	+2.35	-3.24	+2.28	-3.38	+2.39	-3.52	+2.49	-3.18	+2.24
1.011	-3.22	+2.26	-3.18	+2.23	-3.30	+2.32	-3.34	+2.35	-3.24	+2.27	-3.38	+2.39	-3.52	+2.49	-3.18	+2.24
1.017	-3.22	+2.26	-3.18	+2.23	-3.30	+2.32	-3.34	+2.35	-3.24	+2.27	-3.38	+2.39	-3.52	+2.49	-3.18	+2.23
1.023	-3.22	+2.26	-3.18	+2.23	-3.30	+2.32	-3.34	+2.34	-3.24	+2.27	-3.38	+2.39	-3.52	+2.48	-3.18	+2.23
1.028	-3.22	+2.26	-3.18	+2.23	-3.30	+2.32	-3.34	+2.20	-3.24	+2.12	-3.38	+2.38	-3.52	+2.48	-3.18	+2.23
1.031	-3.02	+2.11	-2.99	+2.08	-3.10	+2.17	-3.14	+2.19	-3.04	+2.12	-3.19	+2.23	-3.32	+2.33	-2.99	+2.08
1.034	-3.02	+2.10	-2.99	+2.08	-3.10	+2.17	-3.14	+2.19	-3.04	+2.12	-3.19	+2.23	-3.32	+2.33	-2.99	+2.08
1.037	-3.02	+2.10	-2.99	+2.07	-3.10	+2.17	-3.14	+ 2.19	-3.04	+2.12	-3.19	+2.23	-3.32	+2.33	-2.99	+2.08
1.039	-3.02	+2.10	-2.99	+2.08	-3.10	+2.17	-3.14	+2.19	-3.04	+2.12	-3.19	+2.23	-3.32	+2.33	-2.99	+2.08
1.043	-3.02	+2.10	-2.99	+2.07	-3.10	+2.16	-3.14	+2.19	-3.04	+2.12	-3.19	+2.23	-3.32	+2.33	-2.99	+2.08
1.046	-3.02	+2.10	-2.99	+2.07	-3.10	+2.16	-3.14	+2.19	-3.04	+2.12	-3.19	+2.23	-3.32	+2.33	-2.99	+2.08
1.049	-3.02	+2.10	-2.99	+2.07	-3.10	+2.16	-3.14	+2.19	-3.04	+2.12	-3.19	+2.23	-3.32	+2.33	-2.99	+2.08
1.088	-2.57	+1.75	-2.53	+1.72	-2.65	+1.81	-2.67	+1.84	-2.59	+1.77	-2.74	+1.87	-2.87	+1.97	-2.54	+1.73
1.128	-2.57	+1.74	-2.53	+1.71	-2.65	+1.80	-2.67	+1.83	-2.59	+1.75	-2.74	+1.86	-2.87	+1.96	-2.54	+1.71
1.171	-2.57	+1.72	-2.53	+1.70	-2.65	+1.78	-2.67	+1.81	-2.59	+1.74	-2.74	+1.85	-2.87	+1.94	-2.54	+1.70
1.215	-2.57	+1.71	-2.53	+1.68	-2.65	+1.77	-2.67	+1.79	-2.59	+1.72	-2.74	+1.83	-2.87	+1.92	-2.54	+1.68

Note: The values show difference in quantity and quality of children when both type of norms are set at 2 compared to quantity and quality of children in table 5. Quality is expenditure on education of children expressed as a percentage share relative to the expenditure on consumption.

Bibliography

[1] Aaronson, D., Fabian L. and Bhash M. (2014). Fertility Transitions Along the Extensive and Intensive Margins. American Economic Review 104(11), 3701-3724.

[2] Acemoglu D., and Shimer R., (1999). Holdups and Efficiency with Search Frictions. International Economic Review 40(4), 827-849.

[3] Acemoglu, D. (2001). Good Jobs versus Bad Jobs. Journal of Labor Economics 19(1): 1 21.

[4] Adsera, A. (2006a). Marital Fertility and Religion in Spain, 1985 and 1999. Population Studies 60(2), 205-221.

[5] Adsera, A. (2006b). Religion and Changes in Family-Size Norms in Developed Countries. Review of Religious Research 47(3), 271-286.

[6] African Union (2008). Study on the Informal Sector in Africa. Sixth Ordinary Session of the Labor and Social Affairs Commission of the African Union, Addis Ababa.

[7] Akerlof, G.A. (1997). Social Distance and Social Decisions. Econometrica 65(5), 1005-1027.

[8] Altonji J. G. and Card D., (1991). The Effects of Immigration on the Labor Market Outcomes of Less-skilled Natives, in: John M. Abowd and Richard B. Freeman, (eds.), Immigration, trade and the labor market, University of Chicago Press, 201-234.

[9] Anderson, J. E. & M. Larch & Y.V. Yotov (2017). Trade liberalization, growth, and FDI: A structural estimation framework. Conference paper: ZBW – Deutsche Zentralbibliothek fur Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft.

[10] Artuc, E. & F. Docquier & C. Ozden & Ch. Parsons (2015). A global assessment of human capital mobility: the role of non-OECD destinations. World Development 65, 6–26.

[11] Aubry, A. & M. Burzynski & F. Docquier (2016). The welfare impact of global migration in the OECD countries. Journal of International Economics 101, 1–21.

[12] Basu, A.K. & N.H. Chau & R. Kanbur (2015). Contractual Dualism, Market Power and Informality. Economic Journal 125, 1534–1573.

[13] Basu, A.K. & N.H. Chau & Z. Siddique (2012). Tax evasion, minimum wage noncompliance, and informality. Research in Labor Economics 34, 1–53.

[14] Batista, C. & A. Lacuesta & P.C. Vicente (2012). Testing the brain gain hypothesis: Micro evidence from Cape Verde. Journal of Development Economics 97(1), 32–45.

[15] Battisti M. & G. Felbermayr & G. Peri & P. Poutvaara (2014). Immigration, Search and Redistribution: A Quantitative Assessment of Native Welfare, NBER working paper 20131.

[16] Balbo, N., Billari, F.C. and Mills, M. (2013). Fertility in Advanced Societies: A Review of Research. European Journal of Population 29(1), 1-38.

[17] Baudin, T. (2015). Religion and Fertility: The French Connection. Demographic Research, 32(13), 397-420.

[18] Baudin, T., de la Croix,D. and Gobbi, Paula E. (2015), "Fertility and Childlessness in the United States. American Economic Review 105(6), 1852-1882.

[19] Baudin, T., de la Croix,D. and Gobbi, Paula E. (2017). Endogenous Childlessness and Stages of Development. Discussion Paper 36821-1496132047, Centre for Economic Policy Research, UK.

[20] Barro, Robert J. and Becker, G.S. (1989). Fertility Choice in a Model of Economic Growth. Econometrica 57(2), 481-501.

[21] Ben?Gad M., (2004). The Economic Effects of Immigration ? a Dynamic Analysis. Journal of Economic Dynamics and Control 28, 1825?1845.

[22] Ben?Gad M., (2008). Capital?Skill Complementarity and the Immigration Surplus. Review of Economic Dynamics 11, 335?365.

[23] Beine, M., Docquier, F. and Schiff, M. (2013). International Migration, Transfer of Norms and Home Country Fertility. Canadian Journal of Economics 46(4), 1406-1430.

[24] Beine, M. & F. Docquier & H. Rapoport (2001). Brain Drain and Economic Growth: Theory and Evidence. Journal of Development Economics 64(1), 275–89.

[25] Beine, M. & F. Docquier & H. Rapoport (2008). Brain Drain and Human Capital Formation in Developing Countries: Winners and Losers. Economic Journal 118(528), 631–52.

[26] Bhagwati, J. & K. Hamada (1974). The Brain Drain, International Integration of Markets for Professionals and Unemployment: A Theoretical Analysis. Journal of Development Economics 1(1), 19–42.

[27] Bhagwati, J. & C. Rodriguez (1975). Welfare-Theoretical Analysis of the Brain Drain. Working papers from Massachusetts Institute of Technology (MIT), Department of Economics, No 158.

[28] Berry, R.A. & R. Soligo (1969). Some Welfare Aspects of International Migration. Journal of Political Economy 77(5), 778–94.

[29] Bonin H. (2014), Der Beitrag von Ausländern und Künftiger Zuwanderung zum Deutschen Staatshaushalt, Bertelsmann Stiftung.

[30] Borjas G.J., (1999). The Economic Analysis of Immigration. Handbook of Labor Economics 3(A), 1697?1760.

[31] Borjas G.J., (2003). The Labor Demand Curve is Downward Sloping: Reexamining The Impact Of Immigration On The Labor Market. The Quarterly Journal of Economics 118 (4), 1335?1374.

[32] Brezis, E.S. & P.R. Krugman & D. Tsiddon (1993). Leapfrogging in International Competition: A Theory of Cycles in National Technological Leadership. American Economic Review 83(5), 1211-1219.

[33] Cahuc P., Postel-Vinay F., Robin J.-M., (2006). Wage Bargaining with On-the-Job Search: Theory and Evidence. Econometrica 74(2), 323-364.

[34] Chabé-Ferret, B. (2016). Adherence to Cultural Norms and Economic Incentives: Evidence from Fertility Timing Decisions. IZA Discussion Paper No. 10269.

[35] Chand, S. & M.A. Clemens (2008). Skilled Emigration and Skill Creation: A Quasi-experiment. Center for Global Development Working Paper 152.

[36] Charlot, O. & F. Malherbet & M. Ulus (2014). Unemployment Compensation and the Allocation of Labor in Developing Countries. Journal of Public Economic Theory. forthcoming.

[37] Chassamboulli, A. & T. Palivos (2014). A Search-Equilibrium Approach To The Effects Of Immigration On Labor Market Outcomes. International Economic Review 55, 111-129.

[38] Chen, M.A. (2001). Women in the Informal Sector: a Global Picture, the Global Movement. SAIS Review, Winter-Spring 2001.

[39] Clemens, M. (2015). Losing Our Minds? New Research Directions on Skilled Migration and Development. CGD Working Paper 415, September 2015.

[40] Constant A. and Zimmermann K., (2006). The making of Entrepreneurs in Germany: Are Native Men and Immigrants Alike? Small Business Economics 26, 279-300.

[41] Constant A., Shachmurove Y. and Zimmermann K., (2005). The Role of Turkish Immigrants in Entrepreneurial Activities in Germany. PIER Working Paper 05-029.

[42] Constant A. and Rinne U., (2013). Labour Market Information for Migrants and Employers: The Case of Germany. IZA Research Report, 50.

[43] Dasgupta, P, and Dasgupta, A. (2017). Socially Embedded Preferences, Environmental Externalities, and Reproductive Rights. Population and Development Review 43(3), 405-441.

[44] D'Amuri F., Ottaviano G.I.P., and Peri G., (2010). The Labor Market Impact on Immigration in Western Germany in the 1990s. European Economic Review 54, 550?570.

[45] de la Croix, D. and Delavallade, C. (2018). Religions, Fertility and Growth in South-East Asia. International Economic Review forthcoming.

[46] de la Croix, D. and Doepke, M. (2003). Inequality and Growth: Why Differential Fertility Matters. American Economic Review 93, 1091-1113.

[47] de la Croix, D. & F. Docquier (2012). Do brain drain and poverty result from coordination failures? Journal of Economic Growth 17 (1), 1–26.

[48] de Paula, A. & J.A. Scheinkman (2010). Value-Added Taxes, Chain Effects, and Informality. American Economic Journal: Macroeconomics 2 (4), 195–221.

[49] de Paula, A. & J.A. Scheinkman (2011). The Informal Sector: An Equilibrium Model and Some Empirical Evidence from Brazil. Review of Income and Wealth 57, S8–S26.

[50] DESTATIS, Bevoelkerung mit Migrationshintergrund – Ergebnisse des Mikrozensus, Fachserie 1, Reihe 2.2.

[51] DESTATIS, Statistisches Bundesamt, 2015: Fachserie 18 Reihe 1.2: Volkswirtschaftliche Gesamtrechnungen.

[52] Docquier, F. & T. Müller & J. Naval (2017). Informality and Long-Run Growth. Scandinavian Journal of Economics, forthcoming.

[53] Docquier, F. & H. Rapoport (2012). Globalization, brain drain and development. Journal of Economic Literature 50 (3), 681-730.

[54] Dustmann C., Fasani F., Frattini T., Minale L. and Schönberg U., (2016). On the Economics and Politics of Refugee Migration. Economic Policy 32(91), 497-550.

[55] Dustmann C. and Frattini T., (2014). The fiscal effects of immigration to the UK. the Economic Journal 124, F593-F643.

[56] Dustmann C., Frattini T., and Preston I, (2013). The Effect of Immigration along the Distribution of Wages. The Review of Economic Studies 80(1), 145?173.

[57] Dustmann, C., Glitz A., and Vogel T. (2010). Employment, wages, and the economic cycle: Differences between immigrants and natives. European Economic Review 54 (1), 1-17.

[58] Dustmann C. and Preston I., (2012). Comment: Estimating the Effect of Immigration on Wages. Journal of the European Economic Association 10 (1), 216?223.

[59] Felbermayr G., Geis W., and Kohler W., (2010). Restrictive Immigration Policy in Germany: Pains and Gains Foregone? Review of World Economics 146, 1?21.

[60] Felbermayr, G. J. & B. Jung & F. Toubal (2010). Ethnic networks, information, and international trade: Revisiting the evidence. Annals of Economics and Statistics 41–70.

[61] Fernández, R. and Fogli, A. (2006). Fertility: The Role of Culture and Family Experience. Journal of the European Economic Association 4(2-3), 552?561.

[62] Fernández, R. and Fogli, A. (2009). Culture: An Empirical Investigation of Beliefs, Work, and Fertility. American Economic Journal Macroeconomics, 1(1), 146?177.

[63] Feyrer, J. (2009). Trade and income exploiting time series in geography. NBER Working Paper No. 14910.

[64] Funk L., (2012). The German Economy during the Financial and Economic Crisis since 2008/2009: An Unexpected Success Story Revisited. Konrad-Adenauer-Stiftung.

[65] Gautier P. A., (2002). Unemployment and Search Externalities in a Model with heterogeneous Jobs and Workers. Economica 69, 21-40.

[66] Gërxhani, K. (2004). The Informal Sector in Developed and Less Developed Countries: A Literature Survey. Public Choice 120, 267–300.

[67] Gibson, J. & D. McKenzie (2011). The Microeconomic Determinants of Emigration and Return Migration of the Best and Brightest: Evidence from the Pacific. Journal of Development Economics 95(1), 18–29.

[68] Gobbi, P. (2013),"A Model of Voluntary Childlessness. Journal of Population Economics 26(3), 963-982.

[69] Gong, X. & A. van Soest (2002). Wage differentials and mobility in the urban labour market: a panel data analysis for Mexico. Labour Economics 9(4), 513–529.

[70] Grubel, H. & A. Scott. (1966). The International Flow of Human Capital, American Economic Review 56(1/2), 268-274.

[71] Guiso, L., Sapienza, P. and Zingales, L. (2006). Does Culture Affect Economic Outcomes? Journal of Economic Perspectives 20(2), 23-48.

[72] Günther, I. & A. Launov (2012). Informal Employment in Developing Countries. Opportunity or Last Resort? Journal of Development Economics 97, 88–98.

[73] Haan, H.C. (2006). Training for Work in the Informal Micro-Enterprise Sector: Fresh Evidence from Sub-Sahara Africa. Unesco-Unevoc, Springer, The Netherlands

[74] Haque, N.U. & S.-J. Kim (1995). Human Capital Flight': Impact of Migration on Income and Growth. International Monetary Fund Staff Papers 42(3), 577–607.

[75] Hazan, M. and Zoabi.(2014). Do Highly Educated Women Choose Smaller Families? The Economic Journal 125(587), 1191-1226.

[76] Heaton, Tim B. (2011). Does Religion Influence Fertility in Developing Countries. Population Research and Policy Review 30(3), 449-465.

[77] Hendricks, Lutz, (2004). A database of Mincerian earnings regressions. http://www.lhendricks.org/Mincer.htm.

[78] International Labour Office (2002). Decent Work and the Informal Economy. Report of the Director-General, International Labour Conference, 90th Session, Report VI, ILO, Geneva.

[79] ILO/WTO (2009). Globalization and Informal Jobs in Developing Countries.

[80] Iranzo, S. & G. Peri (2009). Migration and trade: Theory with an application to the Eastern-Western European integration. Journal of International Economics 79(1), 1–19.

[81] Javorcik, B.S. & C. Ozden & M. Spatareanu & C. Neagu (2011). Migrant networks and foreign direct investment. Journal of Development Economics 94(2), 231–241.

[82] Kaas L., and Manger C., (2012). Ethnic Discrimination in Germany?s Labour Market: a Field Experiment. German Economic Review 13(1): 1-20.

[83] Kennan, J. (2013). Open borders. Review of Economic Dynamics 16(2), 1-13.

[84] Klein,P. & Ventura, G. (2009). Productivity differences and the dynamic effects of labor movements. Journal of Monetary Economics 56(8), 1059-1073.

[85] Kl¨usener, S., Neels, K. and Kreyenfeld, M. (2013). Family Policies and the Western European Fertility Divide: Insights from a Natural Experiment in Belgium. Population and Development Review, 39(4), 587-610.

[86] Kremer, M. & D. Chen (1999). Income-distribution dynamics with endogenous fertility. American Economic Review 89(2), 155–160.

[87] Kugler, M. & H. Rapoport (2007). International labor and capital flows: Complements or substitutes? Economics Letters 94(2), 155–162.

[88] Kremer, M. and Chen, Daniel L. (2002). Income Distribution Dynamics with Endogenous Fertility. Journal of Economic Growth 7(3), 227-258.

[89] Krugman, P. (1991). History versus Expectations. Quarterly Journal of Economics 106, 651–67.

[90] Leal Ordonez, J.C. (2014). Tax Collection, the Informal Sector, and Productivity. Review of Economic Dynamics 17, 262–286.

[91] Livi-Baci, M. (1997). A Concise History of World Population. Blackwell Publishers, Oxford.

[92] Maloney, W.F. (2004). Informality Revisited. World Development 32, 1159–1178.

[93] Manacorda M., Manning A., and Wadsworth J., (2012). The Impact of Immigration on the Structure of Wages: Theory and Evidence from Britain. Journal of the European Economic Association 10 (1), 120-151.

[94] Manski, C. F. (1993). Identification of Endogenous Social Effects: The Reflection Problem. Review of Economic Studies, 60(3), 531-542.

[95] Margolis, D.N. & L. Navarro & D. Robalino (2012). Unemployment Insurance, Job Search and Informal Employment. IZA Discussion Paper 6660.

[96] McCulloch, R. & J.L. Yellen (1977). Factor Mobility, Regional Development, and the Distribution of Income. Journal of Political Economy 85(1),79–96.

[97] McKinsey (Global Institute) (2012). Africa at Work: Job Creation and Inclusive Growth.

[98] Melkersson, M. and Rooth, Dan-Olof. (2000). Modeling Female Fertility Using Inflated Count Data Models. Journal of Population Economics, 13(2), 189-203.

[99] Miyagiwa, K. (1991). Scale Economies in Education and the Brain Drain Problem. International Economic Review 32(3), 743–59.

[100] Mookherjee, D. & D. Ray (2003). Persistent inequality. Review of Economic Studies 70, 369-393.

[101] Moreno-Galbis, E. & A. Tritah (2016). The effects of immigration in frictional labor markets: Theory and empirical evidence from EU countries. European Economic Review 84(C), 76-98.

[102] Moretti E., (2010a). Local Multipliers, Papers and proceedings of the 122nd Annual Meeting of the American Economic Association. The American Economic Review 373-377.

[103] Moretti E., (2010b). Local Labor Markets, IZA Discussion paper No. 4905.

[104] Mountford, A. (1997). Can a Brain Drain Be Good for Growth in the Source Economy? Journal of Development Economics 53(2), 287–303.

[105] Munshi, K. and Myaux, J. (2006). Social Norms and the Fertility Transition. Journal of Development Economics, 80, 1?38.

[106] Möller J., (2010). The German Labour Market Response in the World Recession – De-mystifying a miracle. Zeitung für Arbeitsmarktforschung 42(4), 325-336.

[107] Murphy, K.M. & A. Shleifer & R.W. Vishny (1989). Industrialization and the Big Push. Journal of Political Economy 97, 1003–1026.

[108] Murphy, K.M. & A. Shleifer & R.W. Vishny (1991). The Allocation of Talent: Implications for Growth. Quarterly Journal of Economics 106(2), 503-530

[109] MÃtzke, M. and Ilona O. (2010). Introduction: Change and Continuity in Recent Family Policies. Journal of European Social Policy 20(5), 387-398.

[110] Ortega J., (2000). Pareto-Improving Immigration in an Economy with Equilibrium Unemployment. The Economic Journal, 110, 92-112.

[111] Nanos P., and Schluter C., (2014). The Composition of Wage Differentials Between Migrants and Natives. European Economic Review 65, 23-44.

[112] Ngai R., and Pissarides C. A., (2004). Structural Change in a Multi-Sector Model of Growth. CEPR Discussion Paper No. 4763.

[113] Nguyen, Q. and Raju, D. (2014). Private School Participation in Pakistan. Policy Research Working Paper, No. 6897. World Bank, Washington, DC. World Bank.

[114] Ortega J., (2000). Pareto-Improving Immigration in an Economy with Equilibrium Unemployment. The Economic Journal 110 (January), 92-112.

[115] Ottaviano, G.I. & G. Peri (2012). Rethinking the e?ect of immigration on wages. Journal of the European Economic Association 10(1), 152-197.

[116] Pakistan Demographic Survey (1992). Federal Bureau of Statistics, Karachi:Statistics Division.

[117] Pakistan Demographic and Household Survey Survey (1990-91).

[118] Pakistan Demographic and Household Survey Survey (2012-13).

[119] Parsons, C. R. & P.L. Vezina (2017). Migrant networks and trade: The Vietnamese boat people as a natural experiment. The Economic Journal, forthcoming.

[120] Pissarides, C. (2000). Equilibrium Unemployment Theory. Second edition. MIT Press, Cambridge, MA, pp. 252.

[121] Rebien M., Stops M., Zaharieva A, (2017). Formal Search and Referrals from a Firm's Perspective. IMW Working paper Nr. 578, Center for Mathematical Economics, Bielefeld, Germany.

[122] Robalino, D. & M. Weber (2013). Designing and implementing unemployment benefit systems in middle and low income countries: beyond risk-pooling vs savings. IZA Journal of Labor Policy 2(1), 1–20.

[123] Rodriguez, C. (1975). On the Welfare Aspects of International Migration. Journal of Political Economy 83(5), 1065–1072.

[124] Rodrik, D. (2013). Unconditional Convergence in Manufacturing, Quarterly Journal of Economics 128(1), 165–204.

[125] Sander, W. (1992). Catholicism and the Economics of Fertility. Population Studies: A Journal of Demography 46, 477-489.

[126] Salikutluk Z. Gieseke J. and Kroh M., (2016). Geflüchtete nahmen in Deutschland später eine Erwerbstätigkeit auf als andere MigrantInnen, DIW Wochenbericht – Integration Geflüchteter 35, 749-756.

[127] Satchi, M. & Temple, J. (2009). Online Appendix for "Labor Markets and Productivity in Developing Countries". Technical Appendices 06-167, Review of Economic Dynamics.

[128] Sathar, Zeba A. and Casterline, John B. (1998). The Onset of Fertility Transition in Pakistan. Population and Development Review 24(4), 773-796.

[129] Schneider, F. (2005). Shadow Economies around the World: What do we really know?. European Journal of Political Economy 21, 598–642.

[130] Schmidt C. M., Stilz A. and Zimmermann K. F., (1994). Mass Migration, Unions, and Government Intervention. Journal of Public Economics 55, 185-201.

[131] Schneider, F. (2014). The Shadow Economy and Shadow Labor Force: A Survey of Recent Developments. IZA Discussion Paper 8278.

[132] Shrestha, S.A (2017). No man left behind: Effects of emigration prospects on educational and labour outcomes of non-migrants. Economic Journal 127(600), 495–521.

[133] Spolaore, E. and Wacziarg, R. (2016). Fertility and Modernity. UCLA CCPR Population Working Papers, Available at:http://papers.ccpr.ucla.edu/index.php/pwp/article/view/PWP-CCPR-2016-016, latest date accessed: 24 Nov, 2017.

[134] Statistik der Bundesagentur fuer Arbeit, Arbeitsmarkt in Deutschland – Zeitreihen bis 2010, July 2014.

[135] Stichnoth, H. and Yeter, M. (2013). Cultural Influences on the Fertility Behaviour of First and Second Generation Immigrants in Germany. ZEW Discussion Papers 13-023. ZEW-Zentrum fur Europaische Wirtschaftsforschung / Center for European Economic Research.

[136] Stark, O. & C. Helmenstein & A. Prskawetz (1997). A Brain Gain with a Brain Drain. Economics Letters 55(2), 227–34.

[137] Stark, O. & C. Helmenstein & A. Prskawetz (1998). Human Capital Depletion, Human Capital Formation, and Migration: A Blessing or a 'Curse?. Economics Letters 60(3), 363–67.

[138] Theoharides, C. (2017). Manila to Malaysia, Quezon to Qatar: International Migration and its Effects on Origin-Country Human Capital. Journal of Human Resources, forthcoming.

[139] Thomson, E. and Goldman, P. (1987). Measuring Fertility Norms. Population and Environment 9(3), 73-185.

[140] United Nations (2015). UN Commission for Africa

[141] Verick, S.(2008). The Impact of Globalization on the Informal Sector in Africa. Economic and Social Policy Division, UNECA, Addis Ababa.

[142] Vodopivec, M. (2013). Introducing unemployment insurance to developing countries. IZA Journal of Labor Policy 2(1), 1–23.

[143] Walther, R. (2006). Vocational Training in the Informal Sector: Report on the South Africa Field Survey. Working Paper No. 30, Department of Research, Agence Francaise de Developpement, Paris.

[144] World Bank (2014). The State of Social Safety Nets. The World Bank, Washington, DC.

[145] World Bank (2016). World Development Indicators. The World Bank, Washington, DC.

[146] World Development Indicators (2016).

[147] Yashiv, E. (2000). The Determinants of Equilibrium Unemployment. American Economic Review 90(5), 1297–1322

[148] Zenou, Y. (2008). Job Search and Mobility in Developing ountries. Theory and Policy Implications. Journal of Development Economics. Vol.86, 336–355.