Migration, Unemployment, and Over-qualification: A Specific-Factors Model Approach

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3 December 2012

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December 6, 2012

Abstract

This paper analyses the impact of the skill composition of migration flows on the host country's labour market in a specific-factors-two-sector model with heterogeneous labour (low, medium, and high skill) and price- and wage-setting behaviour. The low- and medium-skilled labour markets are characterized by frictions due to wage bargaining. Moreover, we assume bumping down of unemployed medium-skilled workers into low-skilled labour supply. Endogenous benefits create an interdependency between the two bargaining processes. Particular attention is paid to medium-skilled migration which enables us to augment the literature by replicating important stylized facts regarding medium skills, such as i) the interaction between immigration, low-skilled unemployment and medium-skilled over-qualification, ii) the polarization effect where both low- and high-skilled wages increase relative to the medium-skilled. The model is calibrated using German data. The key findings are: (i) a migration-induced supply shock of medium-skilled workers decreases the low-skilled unemployment rate because of the endogenous benefits; (ii) immigration of medium-skilled labour together with some high-skilled labour has a positive effect on output per capita; (iii) migration of only medium-skilled labour has a neutral impact on GDP per capita.

Keywords Medium-Skilled Migration · Wage and Price Setting · Specific Factors Model · Unemployment · Over-qualification · Wage Polarization

JEL F22 · J51 · J52 · J61 · J64

*The authors are grateful for valuable comments and discussions to Herbert Brücker and Klaus Prettner, as well as to participants at NAKE Research Day 2011 at the University of Utrecht, at 17th Spring Meeting of Young Economists at the ZEW in Mannheim 2012, at EALE 2012 in Bonn, at IAB in Nürnberg. Earlier version was circulated under the title: "The Impact of Medium-Skilled Immigration: A General Equilibrium Approach".

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1 Introduction

With the end of the transitional periods as of May 2011 the debate concerning the East-West migration has revived in countries like Germany and Austria, the closest countries to those new members, that had fully prolonged the transitional periods up to seven years.[1] The central concern regarding immigration is the general perception that it will adversely affect the receiving country. Typically, the debate clusters around the following topics: the labour market effects, welfare effects, and racial or cultural effects (Dustmann & Preston, 2007).[2] We focus here on the labour market effects. The empirical evidence on the overall (average) natives wage and employment effects of immigration is rather mixed and clusters around zero (Borjas, 2003; Dustmann et al., 2008), while economic theory provides clear grounds for the "potential impact" of migration. In general, the adjustment mechanisms of the receiving economy to immigration are: changes in wages, in employment, in output, in goods prices, and in production technology (Dustmann et al., 2008).

In spite of an overall negligible effect, it is well recognized that immigration has a distributional effect for the native population which depends crucially on factors such as changes in the skill structure, the substitutability between natives and immigrants, and the elasticity of capital supply (see, for instance, Borjas (2003); Ottaviano & Peri (2008, 2011) for a study on the U.S. labour market, and Brücker & Jahn (2011); D'Amuri, Ottaviano & Peri (2010); Felbermayr, Geis & Kohler (2010), for a study on the German labour market). The findings of these studies reveal that the easier substitutability becomes, the larger the burden is for native workers, while perfectly elastic capital supply induces the so-called "immigration surplus" (Borjas, 1995).[3] This type of analysis denotes the shifts in the relative factor demand.

Additionally, the empirical evidence indicates that immigrants face a higher risk of being *downgraded* or *over-qualified* (see OECD (2007) for a cross-

[1] On 1 May 2004, eight CEECs, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, and Slovenia plus two Mediterranean countries Malta and Cyprus joined the EU with Bulgaria and Romania followed on 1 January 2007.

[2] Several recent studies show that in general attitudes towards immigration are heterogeneous across native population and depend on the labour market situations, welfare consideration and non-economic factors (see, for example, Dustmann & Preston, 2007; Dustmann, Glitz & Frattini, 2008; Facchini & Mayda, 2008; Mayda, 2006). However, income effects are more important in the welfare debate while educational background plays a dominant role in the labour market debate. See also Boeri & Brücker (2005) for a discussion on concerns regarding "welfare shopping".

[3] The main conclusion of these recent studies, using the canonical model (multi-nested production technology), is that natives and immigrants are imperfect substitutes and that newly arrived immigrants compete mostly with incumbent immigrants rather than with native workers with similar characteristics.

country evidence; Drinkwater, Eade & Garapich (2009); Dustmann, Frattini & Preston (2012) for recent evidence in the U.K.). However, across the skill groups the medium-skilled workers have a higher tendency to be over-qualified relative to high-skilled workers (see Brynin & Longhi, 2009, for Germany). This type of analysis emphasizes, in addition, the shifts in the labour supply and justifies the anxieties of the least skilled natives regarding displacement effects.[4] In this paper, we revisit the labour market effects by using a different approach to address both shifts in the relative labour demand indicating the "substitution effect" as well as shifts in the labour supply indicating the "crowding-out effect".

In order to incorporate the different adjustment channels of immigration, we develop a two-sector ("Manufacturing" and "Services") model with workers of different skills: "High", those with a tertiary education, "Medium", those with a upper secondary education and apprenticeship training, and "Low", those with lower secondary or no formal qualification. High-skilled workers are perfectly mobile between the two sectors while medium-skilled workers are only employed in the manufacturing sector and low-skilled workers only employed in the service sector. In particular, the labour markets of specific factors are plagued by frictions due to wage bargaining. In line with the evidence discussed above and for simplicity, we assume that unemployed medium-skilled workers turn to the service sector by performing low-skilled jobs, whereas low-skilled workers end up in unemployment. Furthermore, firms in both sectors possess the monopoly power to set the goods prices for a final consumption-good producer, thus allowing for endogenous goods prices. We then examine the general equilibrium effects of an *infra-marginal* (i.e. a discontinuous jump) increase in the labour force due to immigration.

Our analysis in this paper is novel relative to those papers examining simultaneously the impact of immigration on wages and employment for different skill groups with labour market friction (such as Brücker & Jahn, 2011; D'Amuri et al., 2010; Felbermayr et al., 2010) because it also incorporates sectoral composition and endogenous goods price effects. On the other hand it is also novel relative to those papers that elaborate the goods price effects and sectoral composition effects of immigration (such as Cortes, 2008; Felbermayr & Kohler, 2006, 2007) because it includes labour market frictions.

[4]For example, Dustmann et al. (2012) empirically assess the immigration effect along the wage distribution. Although the newly arrived immigrants to the U.K. have on average higher educational attainment, the authors find that they are located at the *lower end* of the wage distribution (indicating the downgrading/over-qualification effect). Their results show a decline of the wages below the 20th percentile while wages above the 40th percentile have increased.

Particularly, our model enables us to address the concerns regarding the interaction between immigration, low-skilled unemployment and medium-skilled over-qualification.[5]

An important feature of the model is that it is capable to replicate the evidence regarding low wage differential at the lower end of the wage distribution in Germany due to unions wage compression (Dustmann & Schönberg, 2009). This is incorporated in our framework by the wage linkage between the low- and medium-skilled labour markets resulting from the wage bargaining process and endogenous unemployment benefits.

Another interesting observation that has recently attracted the attention is the so-called "polarization" phenomenon in many developed countries (cf. Autor & Dorn, 2010; Dustmann, Ludsteck & Schönberg, 2009; Goos, Manning & Salomons, 2009; Spitz-Oener, 2006). As we show in the next section, the medium-skilled wages relative to low- and high-skilled have decreased in both sectors between 1991-2005 in Germany. However, although Dustmann et al. (2009) find evidence for polarization in occupation in Germany in the same period, their results regarding wage convergence between low-and medium-skilled workers is not significant. Actually, the authors observe an increase in the wage inequality at the bottom of the wage distribution and the rationale for this is a supply shock of low-skilled workers in the 1990s induced by the break down of the Soviet Union. Similarly, we argue that the recent migration pattern from Eastern to Western European countries (i.e. in the 2000s) might explain the wage polarization induced by a relative supply shock of medium-skilled workers.[6] This is the next novelty of our paper as it enables us to replicate important stylized facts regarding medium skills discussed in the next section.[7]

In general, our model, calibrated to the German economy, generates the following interesting predictions:

- Due to the wage linkage, a migration-induced supply shock of medium-skilled workers generates a *decline* in the low-skilled unemployment rate.
- The stronger the wage linkage, the lower the wage differential between the low and medium skill groups owing to immigration.
- A supply shock of medium-skilled workers generates wage polarization

[5]Beladi (1990) shows that of specific factor accumulation can increase the total employment in an unemployment-plagued economy. However, he neither incorporates goods price effects nor heterogeneous labour force.

[6]See Kahanec & Zimmermann (2010) for a survey on recent migration pattern in the course of the EU enlargement and Blanchflower, Saleheen & Shadforth (2007) for recent pattern in the UK.

[7]Storesletten (2000) is an exception doing generational accounting for medium-skilled migration.

and has approximately a neutral GDP per capita effect.

The set up of the paper is as follows. The next section presents the stylized facts on migration pattern, labour market composition, and trends in employment and wages in the manufacturing and service sectors for Germany. In section 3 we demonstrate the theoretical framework with two major sectors, three skill groups and a double wage bargaining model determining the wages of medium- and low-skilled labour. In section 4, we provide first a qualitative assessment of the comparative static analysis, derived by means of log-linearisation around the steady-state, followed by an intuitive interpretation of the theoretical results. In section 5, we calibrate the model for Germany using the EUKLEMS data set to measure the quantitative importance of various migration scenarios. Finally, section 6 presents the concluding remarks.

2 Stylized facts

At the aggregated level, the average impact of immigration on unemployment and wages of native workers has been explored quite extensively and tend to cluster around zero, as discussed above. However, as already emphasized, the literature on migration has somehow ignored the potential impact of medium-skilled work force, although it accounts for a large part of the total labour force as well as of the foreign work force nowadays. Table 1 highlights this feature in the case of Germany by showing the composition of the total labour force across manufacturing and service sectors as well as of the foreign labour force by skill groups for the years 1991 and 2005. Noticeable, the most pronounced increase was in the share of foreign medium-skilled labour.

Table 1: Total and foreign labour force, by education groups

	1991				2005			
	Total			Mig.	Total			Mig.
Skills	Agg.	Manuf.	Serv.		Agg.	Manuf.	Serv.	
High (%)	8	6	9	4	10	7	10	6
Medium (%)	64	63	65	48	62	66	61	61
Low (%)	28	31	25	48	28	27	28	33

Notes: Agg.=Aggregate, Manuf.=Manufacturing, Serv.=Services, Mig.=Migrants. The total shares denote the shares in hours worked, and are calculated from EU KLEMS. The number for foreigners are taken from Brücker & Jahn (2011), but denoting, respectively, the years 1990 and 2004. Medium-skilled consists of the educational groups: vocational and high-school.

Another phenomenon that has recently attracted the attention is the job

Table 2: Changes in wage rates and employment shares, by education and industry

	1991 – 2005	
	Wage Rate	Employment Share
Manufacturing Sector (in %)		
High	59	25
Medium	40	4
Low	42	−15
Service Sector (in %)		
High	44	13
Medium	36	−7
Low	41	5

Notes: The numbers denote log-differences. Employment shares designate the shares in hours worked. *Source*: EU KLEMS.

polarization phenomenon in many developed countries. Table 2 presents this for Germany where we show the percentage changes in the total employment shares as well as in the wage rates by education and industry for the period 1991-2005. One sees clearly that high-skilled employment shares increased in both sectors, whereas the low-skilled share in manufacturing declined and the medium-skilled share in services. Moreover, both low- and high-skilled wages grew faster relative to medium-skilled wages reflecting the U-shaped trend found in the empirical literature (see, for example, Autor & Dorn (2010) for the U.S. and Goos et al. (2009) for Europe). While the main rationale behind this trend is explained by the advances in information and communication technology (see, for instance, Van Reenen, Michaels & Natraj (2010)), this paper gives an alternative explanation. We show that it might also be due to relative increase in the medium-skilled labour force due to migration. This brings us to the next stylized fact.

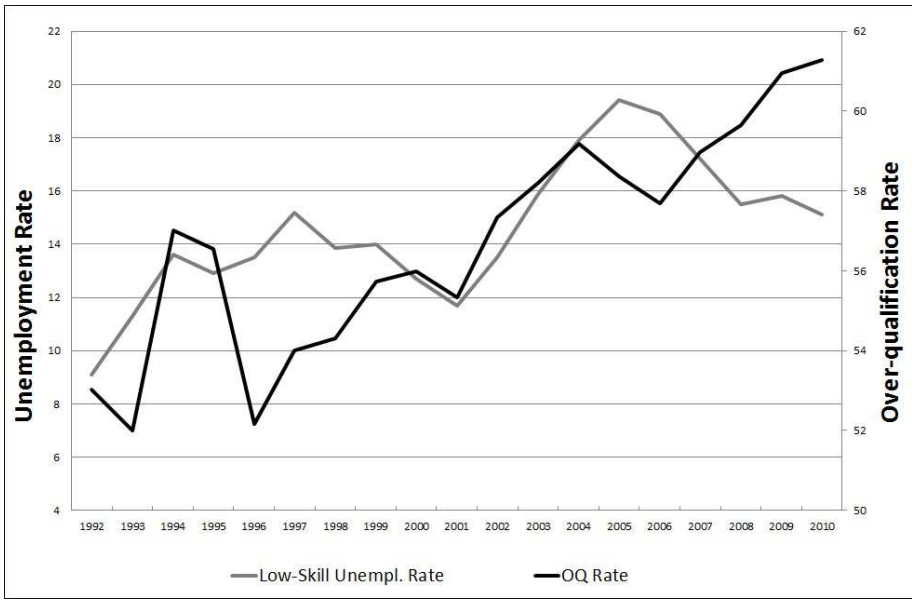
A study by OECD (2007) documents that the labour market performance of immigrants is denoted by higher risk of *over-qualification*. Recent studies on post-EU-enlargement provide further evidence. For example, Drinkwater et al. (2009) analyse the performance of Polish immigrants in the UK labour market and find that majority of them are employed in low-skilled and low-paid jobs despite having relatively high levels of education.[8]

Moreover, a recent study by Brynin & Longhi (2009) finds for Germany, using households survey data, a relative excess of over-qualification at the medium-skilled level which contributes to almost half of all overqualified persons. This indicates that beside the standard argumentation of denoting the technical change as the main deriving force behind the increase in low-skilled

[8]See also Kahanec & Zimmermann (2010) for a review of the recent literature.

unemployment rate, the increase in the low-skilled unemployment rate might be the consequence of an increase in supply of better educated workers leading to the so called "crowding-out" of low-skilled workers. Using German data,

Figure 1: Trends in low-skilled unemployment and over-qualification rates



Note: The over-qualification (OQ) rate denotes the proportion of medium-skilled workers in low-skilled jobs. *Source*: Eurostat.

Figure 1 shows the relation between low-skilled unemployment rate and the proportion of medium-skilled workers in low-skilled type of jobs. Except for 2000-2004 (the ICT bust period) where a positive relation can be seen, it designates a reverse relation, especially, in the recent years. This observation might be the result of changes in the labour market institutions in 2005 (also known as *Hartz* reforms).

We summarize these stylized facts as follows

1. Medium-skilled workers constitute a major component of the labour force and of immigrants
2. High-skilled employment rises in both sectors with low-skilled declining in manufacturing sector and medium-skilled in service sector
3. Medium-skilled labour has a higher incidence of over-qualification
4. There is a negative relation between the over-qualification rate in low-skilled jobs and the low-skilled unemployment rate
5. Both low-skilled and high-skilled wages have increased relative to the medium-skilled wage, which points at wage polarization

3 The theoretical framework

The economy is defined by two major sectors, *manufacturing* (Y_m) and *services* (Y_s), each producing a good by utilizing physical capital and labour. These two goods are in turn used in a CES aggregate to produce a final consumption good (X). We interpret X as the total GDP which is taken as the numeraire, i.e. its price is set to unity. The CES aggregate can be interpreted as the production technology of a final good sector or as the utility function of a representative household. In light of the stylized facts reported in Section 2, we assume that medium-skilled labour is specific to manufacturing sector and low-skilled labour specific to the services sector - although bumping down of medium skilled labour to low skilled service jobs can occur. Capital and high-skilled labour are employed in both sectors. We assume that firms in manufacturing and services sectors have a monopoly power which is ensured by a fixed entry cost. The high skilled wage is determined on a competitive labour market, but medium and low skilled wages are determined by wage bargaining. We elaborate these points below in the context of a general equilibrium framework.

3.1 Final consumption good

The final consumption good (or the GDP) is produced by the following CES function

$$X = \left(\gamma Y_m^{\frac{\theta-1}{\theta}} + (1-\gamma) Y_s^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}} \tag{1}$$

where $\theta > 1$ denotes the elasticity of substitution between the two sectors and $0 < \gamma < 1$ is the distribution parameter. From (1), we obtain the isoelastic demand functions for manufacturing and service goods

$$Y_m^d = \gamma^\theta X \left(\frac{P_m}{P}\right)^{-\theta} \tag{2a}$$

$$Y_s^d = (1-\gamma)^\theta X \left(\frac{P_s}{P}\right)^{-\theta} \tag{2b}$$

respectively, where $P = \left((1-\gamma)^\theta P_s^{1-\theta} + \gamma^\theta P_m^{1-\theta}\right)^{\frac{1}{1-\theta}}$ denotes the macroeconomic price index which is taken as numeraire in the remaining part of the analysis. As a consequence all variables are defined in real terms and we assume no inflation.

3.2 Manufacturing and services goods

After incurring a fixed cost, firms in both sectors produce a good with a standard Cobb-Douglas production technology with constant returns to scale. Note that positive profits are ensured simply by the assumption of relatively high fixed costs such that free-entry is ruled out, see Cahuc & Zylberberg (2004, Ch. 7) for a general discussion. Based on our discussion above, in the manufacturing sector high- (H_m) and medium-skilled (M) labour are employed, whereas in the service sector high- (H_s) and low-skilled (L) labour are utilized. The production functions for manufacturing and services are given by

$$Y_m = AK_m^{\nu} H_m^{\alpha} M^{1-\alpha-\nu} \tag{3a}$$

$$Y_s = BK_s^{\eta} H_s^{\beta} L^{1-\beta-\eta} \tag{3b}$$

respectively, where $0 < \{\alpha, \beta, \nu, \eta\} < 1$. The total factor productivity in manufacturing and services is denoted by exogenous variables A and B, respectively, with $A > B$ reflecting the higher productivity of manufacturing relative to services.

3.3 Factor demand

Firms determine factor demand by minimizing their costs given the factor prices. The rental cost of capital, r^*, is determined on the international capital market since capital is assumed to be perfectly mobile.[9] Furthermore, high skilled workers are assumed to be mobile between the service and manufacturing sectors. As a consequence the high-skilled wage is equalized between the two sectors: $w_H^m = w_H^s = w_H$. The wage bargaining in the medium skilled and the low skilled labour markets determine w_M and w_L, respectively. Factor demand, then, is determined by minimizing the manufacturing production costs

$$C_m = w_H H_m + w_M M + r^* K_m \tag{4}$$

subject to production technology (3a). Similarly, factor demand in the service sector is determined by minimizing the service production costs

$$C_s = w_H H_s + w_L L + r^* K_s \tag{5}$$

[9]For simplicity, we assume that intra-trade is balanced in each sector. For a terms-of-trade effect see Felbermayr & Kohler (2007).

subject to the production technology (3b). Solving the optimization problems, the factor demand functions in the manufacturing sector are given by

$$H_m^d = \alpha \frac{Y_m}{A} \left(\frac{w_H}{W^m} \right)^{-1} \tag{6a}$$

$$M^d = (1 - \alpha - \nu) \frac{Y_m}{A} \left(\frac{w_M}{W^m} \right)^{-1} \tag{6b}$$

$$K_m^d = \nu \frac{Y_m}{A} \left(\frac{r^*}{W^m} \right)^{-1} \tag{6c}$$

and in the services sector by

$$H_s^d = \beta \frac{Y_s}{B} \left(\frac{w_H}{W^s} \right)^{-1} \tag{7a}$$

$$L^d = (1 - \beta - \eta) \frac{Y_s}{B} \left(\frac{w_L}{W^s} \right)^{-1} \tag{7b}$$

$$K_s^d = \eta \frac{Y_s}{B} \left(\frac{r^*}{W^s} \right)^{-1} \tag{7c}$$

where $W^m = \left(\frac{r^*}{\nu}\right)^{\nu} \left(\frac{w_H}{\alpha}\right)^{\alpha} \left(\frac{w_M}{1-\alpha-\nu}\right)^{1-\alpha-\nu}$ and $W^s = \left(\frac{r^*}{\eta}\right)^{\eta} \left(\frac{w_H}{\beta}\right)^{\beta} \left(\frac{w_L}{1-\beta-\eta}\right)^{1-\beta-\eta}$ denote the geometric weighted average factor price composite in the manufacturing and services sectors, respectively.

Substituting (6a)-(6c) into the cost function, (4), and similarly (7a)-(7c) into (5), we obtain the minimized cost functions

$$C_m^*(w_H, w_M, r^*) = \frac{W^m}{A} Y_m \tag{8a}$$

$$C_s^*(w_H, w_L, r^*) = \frac{W^s}{B} Y_s \tag{8b}$$

for manufacturing and service good producers, respectively.

3.4 Price setting for intermediate goods

As shown in the previous section, firms in the two major sectors face a downward-sloping domestic demand function for their products. Therefore, a representative manufacturing good producer sets the price of her good by maximizing her profit

$$\Pi_m = P_m Y_m - C_m^*(W^m, Y_m) \tag{9}$$

subject to (2a). Similarly, a representative service good producer maximizes her profit

$$\Pi_s = P_s Y_s - C_s^*(W^s, Y_s) \tag{10}$$

subject to (2b). Solving the maximization problems, yield the standard pricing behaviour, respectively, in the manufacturing and service sectors

$$P_m = \frac{\theta}{\theta - 1}\frac{W^m}{A} \tag{11a}$$

$$P_s = \frac{\theta}{\theta - 1}\frac{W^s}{B}. \tag{11b}$$

3.5 Wage setting and the labour market features

As discussed above, high skilled workers are mobile between the two intermediate sectors, and we assume labour market clearing for them. However, in line with the European labour market institutions, wage bargaining occurs in both low- and medium-skilled labour markets - see, for example,Brücker & Jahn (2011) where wage-setting curves differ across sectors. In our framework two different labour unions negotiate the wages for medium- and low-skilled workers in the manufacturing and services sectors, respectively. But, as we elaborate below, wages are not independent. On the one hand medium skilled workers can be bumped down into the service jobs, earning low-skilled wages, which influences the reference wage of medium skilled workers. On the other hand, medium skilled wages will have an impact on the level of the benefits, which will influence the reference wage of low skilled workers.

Following Booth (1995) and Layard, Nickell & Jackman (2005), wages are determined by the *right-to-manage* bargaining solution so that the negotiating parties only bargain over the wages, whereas the optimal employment decisions is made by the firms. In doing so, we also follow the conventional way by assuming that in each sector there exists a continuum of identical firms and unions and therefore neglect firm-union-specific indices (cf. Koskela & Stenbacka, 2009, 2010). Firm's net gain is simply the flow of profits, i.e. net of the fixed costs. This is given for the manufacturing and services firms, respectively, by the equations (9) and (10). The net gain for the labour union is simply the net result of the bargained wage and the outside option. Thus, the objective function of the manufacturing and service labour unions is given, respectively, by

$$U_m = (w_M - \bar{w}_M)M \tag{12}$$

$$U_s = (w_L - \bar{w}_L)L \tag{13}$$

where $\bar{w}_j, \forall j = L, M$ denotes the outside option which is taken as given by each labour union. Thus, the medium-skilled wage is the result of the following

maximization problem

$$\max_{w_M} \Omega_M \quad = \quad \left((w_M - \bar{w}_M)M^d\right)^{\delta_m} \Pi_m^{1-\delta_m} \quad \text{s.t.}(2a), (6b), (9), (11a)$$

Similarly, the low-skilled wage is set by solving the following maximization problem

$$\max_{w_L} \Omega_L \quad = \quad \left((w_L - \bar{w}_L)L^d\right)^{\delta_s} \Pi_s^{1-\delta_s} \quad \text{s.t.}(2b), (7b), (10), (11b)$$

where δ_i $(i = s, m)$ denotes the bargaining strength of the labour union. The solution of the wage negotiation yields, after some manipulation, the standard result

$$w_j \quad = \quad (1 + \lambda_i)\bar{w}_j \quad \forall \; j = M, L \tag{14}$$

where the mark-up on the medium- and low-skilled outside options is given, respectively, by

$$\lambda_m = \frac{\delta_m}{(1 - \alpha - \nu)(\theta - 1)} \tag{15a}$$

$$\lambda_s = \frac{\delta_s}{(1 - \beta - \eta)(\theta - 1)}. \tag{15b}$$

3.5.1 Manufacturing wage curve

As shown by the stylized facts, medium skilled workers have a relatively high incidence of over qualification. Several empirical studies suggest that a significant and increasing proportion of low-skilled jobs are nowadays carried out by better educated, over-qualified workers - see Borghans & de Grip (2000) and Hartog (2000) for an overview of these studies.

Following these stylized facts, we assume that the medium-skilled workers face the risk of holding a low-skilled job in the services sector when they cannot find employment in the manufacturing sector. As a consequence, they will lead the low-skilled workers into unemployment. This suggests that the rise in low-skilled unemployment would not only be the result of a relative demand shift, but also the consequence of a relative supply shift which leads to "crowding-out" of low-skilled workers as has also been observed by Pierrard & Snessens (2003).

The medium-skilled over-qualification rate is defined by

$$o_M \quad = \quad 1 - \frac{M}{N_M} \tag{16}$$

with N_M as the total medium-skilled labour force.

Since frictions in the medium-skilled labour market is described by the over-qualification risk, then in the general equilibrium context as well as by the symmetry assumption, the reference wage of a medium-skilled worker ($\bar{w}_M$) can be interpreted as:

$$\bar{w}_M = (1 - o_M)w_M + o_M w_L. \tag{17}$$

Substituting this expression into (14) and rearranging, we obtain the manufacturing wage curve (WC_m)

$$w_M = \Phi(\lambda_m, o_M)w_L, \tag{18}$$

where $\Phi(\lambda_m, o_M) = \frac{(1+\lambda_m)o_M}{1-(1+\lambda_m)(1-o_M)}$. That is, as long as the manufacturing union has some bargaining power, $\delta_m > 0$, it will set a markup denoted by $\Phi(\cdot)$ over the low-skilled wage rate. If, however, $\delta_m \to 0$, then $\lambda_m \to 0$ and $w_M \to w_L$ denoting the perfect competition case. One can easily show that $\partial\Phi/\partial o_M < 0$ implying the wage curve is increasing in employment of medium skilled workers.

3.5.2 Service wage curve

The low-skilled unemployment rate is defined by:[10]

$$u_L \;=\; 1 - \frac{L - o_M N_M}{N_L} \tag{19}$$

with N_L denoting the total low-skilled labour force.

Contrary to manufacturing, low-skilled workers face the risk of being unemployed and thus receiving an unemployment benefit, b. Recalling the symmetry assumption, the outside option (or the average income) of the low-skilled workers is defined as:

$$\bar{w}_L = (1 - u_L)w_L + u_L b \tag{20}$$

Furthermore, we assume that the level of benefits is tied closely to the average wage which is in line with the evidence. Weiss & Garloff (2009), for example, show that the level of benefits is tied closely to per-capita income in most European countries while in the Anglo-Saxon countries there was no adjustment

[10]Note, the service trade union does not take into account the crowding-out effect when negotiating over the wage rate and therefore, the *perceived* unemployment rate is simply given by $u_L^p = 1 - \frac{L}{N_L}$. We use this property in the analysis of the interaction between the service and manufacturing wages.

over the last two decades. Consequently, we define b as a percentage (ξ) of average low- and medium-skilled wages weighted by κ:[11]

$$b = \xi(\kappa w_M + (1-\kappa)w_L). \tag{21}$$

Using this definition for b in (20) and substituting then the resulting equation in (14), after rearranging, we obtain the following aggregated service wage curve (WC_s)

$$w_L \;\; = \;\; \Psi(\lambda_s, u_L) w_M \tag{22}$$

where $\Psi(\lambda_s, u_L) = \frac{(1+\lambda_s)\xi\kappa u_L}{(1+\lambda_s)(1-\xi(1-\kappa))u_L - \lambda_s}$. Similarly to the manufacturing wage curve, one can verify that $\partial\Psi/\partial u_L < 0$. Hence the wage curve is increasing in the employment of low-skilled workers. Note that if the service labour union looses the bargaining power, then the perfect competition outcome with no unemployment results, i.e. if $\delta_s \to 0$, then $\lambda_s \to 0$ and $w_L \to b$. Moreover, from 20 and 21 it follows that the higher the weighting parameter κ is, i.e. the stronger the linkage to the medium skill wage, $\frac{\partial\Psi}{\partial\kappa} > 0$. Thus, we conclude

Proposition 1. *A stronger linkage between low- and medium-skilled workers owing to bargaining process and endogenous unemployment benefit, induces wage compression at the lower end of the wage distribution.*

This is in line with the cross-firm evidence for Germany where the wage differential between low and medium skilled workers in unionized firms is lower relative to non-unionized firms (Dustmann & Schönberg, 2009).[12]

3.6 Interaction between low- and medium-skill wages

Due to the risk of over-qualification and the endogenous unemployment benefits, there is an interdependency between the low- and medium-skill wages. We show that the condition for the unique equilibrium is assured by the fact

[11] Note that for $\kappa = 0$ we obtain the standard definition of unemployment benefits as the constant "replacement rate", $b/w_L = \xi$. In this case, however, the linkage between w_L and w_M disappears and the service wage curve will be defined as $w_L = (1+\lambda_s)((1-u_L)w_L + u_L b)$. Consequently, the equilibrium unemployment rate, u_L, will be constant and depends only on the parameters of the model implying that it does not react any longer to a migration shock. However, conducting the quantitative analysis for exogenous unemployment benefits ($\bar{b}$), we find that the unemployment rate responds much stronger. In particular, a supply of medium-skilled workers induces a displacement effect of low-skilled workers. Results will be provided upon request.

[12] Computing the effects for different values for κ, we find that a stronger linkage between low- and medium-skilled workers (i.e. $\kappa \to 1$), reduces the magnitude of changes in relative low-medium skill wages.

that both wage curves are monotonically increasing in the wage rates, starting from positive intercepts. However, the latter requires lower boundaries on both unemployment and over-qualification rates. Moreover, both curves should intersect such that the following relation is ensured, $w_M > w_L > 0$.

We now elaborate on the shape and properties of both wage curves derived in the previous section.

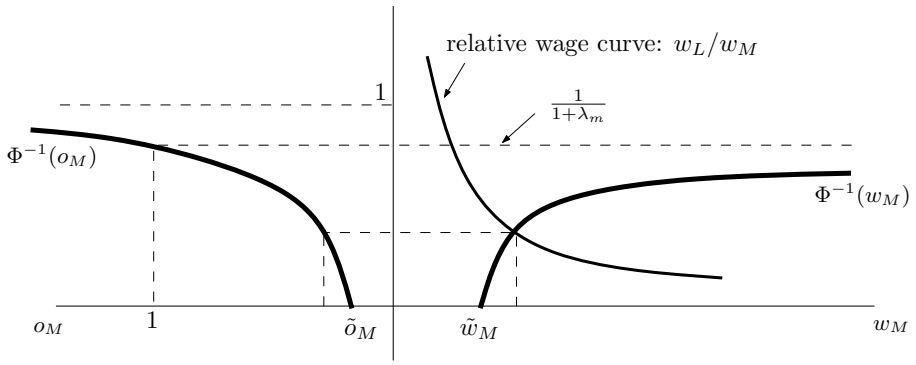
3.6.1 Properties of manufacturing wage curve

The partial features of the manufacturing wage curve (i.e. taking w_L as given), can be demonstrated as follows. For a better realization, rewrite (18) as

$$\frac{w_L}{w_M} = \Phi(\lambda_m, o_M)^{-1} \equiv 1 - \frac{\bar{\lambda}_m}{o_M(w_M)} \tag{23}$$

where $\bar{\lambda}_m = \frac{\lambda_m}{1+\lambda_m}$ and $o_M(w_M)$ is given by (16). Now, the LHS and RHS can both be seen as a function of w_M for given values of w_L. This is because manufacturing unions take the outside option (w_L) as given when they negotiate. Then, it can be easily verified that the LHS of (23) is a decreasing function of w_M but the RHS is increasing for certain values of both o_M and w_M, as will be discussed below. These relationships are illustrated in Figure 2.

Figure 2: Properties of manufacturing wage curve



Consider first the right panel of Figure 2. Then, recalling (18), we can draw two curves: one shows the negative relation between the relative wage rate due to changes in w_M (LHS of (23)) holding the low-skilled wage fixed; the second curve illustrates the positive relation between the inverse-wage-mark-up function (Φ^{-1}) and the medium-skilled wage rate (w_M). This relation follows from the positive relationship between the over-qualification rate and the medium-skilled wage rate as higher wages induces a decline in the labour demand and increase, thus, the risk of over-qualification. Recalling the medium-skilled labour demand (6b) and the over-qualification rate (16), then, one can verify

the limit cases

$$\lim_{w_M \to \infty} M^d = 0 \quad \Rightarrow \quad \lim_{w_M \to \infty} o_M = 1 \quad \Rightarrow \quad \lim_{w_M \to \infty} \Phi^{-1} = \frac{1}{1+\lambda_m}.$$

The intersection between the two curves in the right plane will determine the equilibrium over-qualification rate and medium-skilled wage level for changes in the low-skilled wage rate.

We conclude

Lemma 1. *Positive wages are ensured iff* $o_M \in (\tilde{o}_M, 1)$.

Proof. The proof is rather straight forward. Due to the non-negativity assumption of the wage rates, it follows from (23):

$$\begin{aligned}
\Phi^{-1} &> 0 \\
\frac{\bar{\lambda}_m}{o_M} &< 1 \\
o_M &> \tilde{o}_M \equiv \frac{\lambda_m}{1+\lambda_m} \\
w_M &> \tilde{w}_M \equiv \left[\frac{(1-\alpha-\nu)(r/\nu)^\nu (w_H/\alpha)^\alpha}{N_M} \frac{(1+\lambda_m)Y_m}{A} \right]^{\frac{1}{\alpha+\nu}}
\end{aligned}$$

where we used the over-qualification definition (16) and labour demand function (6b) for the last inequality. This defines the lower boundary of the over-qualification rate. □

3.6.2 Properties of service wage curve

Similarly, the partial behaviour of the service wage-curve can be assessed as follows. First, rewrite (22) as

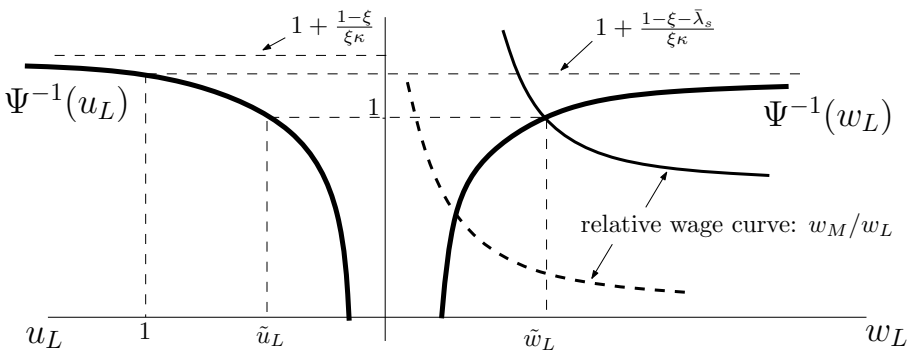
$$\frac{w_M}{w_L} = \Psi(\lambda_s, u_L)^{-1} \equiv 1 + \frac{1-\xi}{\xi\kappa} - \frac{\bar{\lambda}_s}{\xi\kappa u_L} \tag{24}$$

where $\bar{\lambda}_s = \frac{\lambda_s}{1+\lambda_s}$. With the same intention described above, we define both the LHS and RHS of (24) as functions of w_L for given values of w_M. The argumentation is analogue to one on the manufacturing wage curve. Thus, we can define two curves with opposite relations to changes in w_M as shown in the right plane of Figure (3), whereas the left plane shows the relation between (Ψ^{-1}) and the unemployment rate (u_L).

However, the condition that must be satisfied in this case is summarized by the following lemma.

Lemma 2. *The relation* $w_M > w_L$ *is ensured iff* $u_L \in (\tilde{u}_L, 1)$.

Figure 3: Properties of service wage curve



Proof. From (24), it follows:

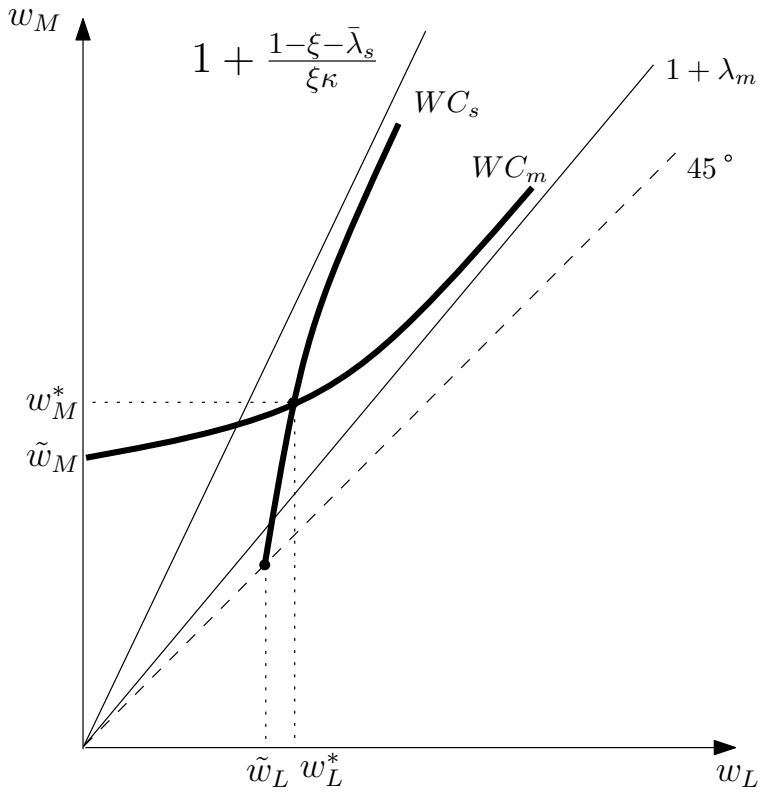
$$\begin{aligned}
\Psi^{-1} &> 1 \\
\frac{\bar{\lambda}_s}{u_L} &< 1-\xi \\
u_L &> \tilde{u}_L \equiv \frac{\bar{\lambda}_s}{1-\xi} \\
w_L &> \tilde{w}_L \equiv \left[\frac{(1-\beta-\eta)(r/\eta)^{\eta}(w_H/\beta)^{\beta}}{((1-q)N_L)}\frac{Y_s}{B}\right]^{\frac{1}{\beta+\eta}}
\end{aligned}$$

where $q \equiv (1-\frac{\bar{\lambda}_s}{1-\xi})$. For the last inequality we used the definition of perceived unemployment rate (explained in footnote 10), and the low-skilled labour demand (7b). This implies that for values of unemployment rate $u_L \in (0, \tilde{u}_L]$ the relation between low- and medium-skilled wage rates is violated, i.e. $w_M \leq w_L$. Therefore, to ensure $w_M > w_L$, the unemployment rate must be strictly larger than the lower boundary $\tilde{u}_L$. □

Now, from these conditions, the unique intersection of the two wage-setting curves can be shown graphically in the (w_M, w_L)-plane. By Lemma 1 and 2, $w_M > w_L > 0$. This indicates that in the (w_M, w_L)-space the wage relation should always be above the 45 degree line. Starting with WC_m, one sees from the RHS plane of Figure 2 that for large values of the low-skilled wage rate, the medium-skilled equilibrium wage rises along the Φ^{-1} curve due to upward shifts of the relative wage curve. Hence, higher w_L increases equilibrium w_M and with it the over-qualification rate which converges to $1+\lambda_m$, the reciprocal of the limit shown in Figure 2.

Analogously, the derivation of WC_s can be explained by recalling the RHS of Figure 3. Now, changes in w_M are associated with moving along the Ψ^{-1} curve. However, as explained above, the necessary condition requires that $\Psi^{-1} > 1$ for $w_L > \tilde{w}_L$. This indicates that in (w_M, w_L)-space the WC_s must

Figure 4: Unique equilibrium



start above the 45 degree line. As described above, higher w_M leads to higher w_L along the Ψ^{-1} curve converging to the limit $1+\frac{1-\xi-\bar{\lambda}_s}{\xi\kappa}$. However, it should be noted that in the (w_M, w_L)-plane, the inverse service wage curve is drawn. To ensure a unique equilibrium, $1+\frac{1-\xi-\bar{\lambda}_s}{\xi\kappa} > 1+\lambda_m$ must hold which leads to the following lemma.

Lemma 3. *A unique intersection between the two wage curves is ensured for all*

$$\xi < \tilde{\xi} \equiv \frac{1}{1+\lambda_s}\frac{1}{1+\kappa\lambda_m}.$$

In Table 3, we summarize these conditions and assume that they hold.[13]

An illustration of the interdependence process is that an increase in productivity of manufacturing, relative to that of services, increases the wage rate in the services sector without any justification by the corresponding productivity increases in the latter. This phenomenon is also widely recognized as the main cause of the so-called *Baumol's disease*, which refers to the increasing share of services relative to manufacturing in an advanced economy - see, for instance, Hartwig (2011). It also corresponds to the observation that the low wage differentiation in the Continental Europe is attributed to the centralization and

[13]In the calibration of the model we show that these conditions do hold for plausible parameter values - see Appendix A.

Table 3: Equilibrium Conditions

Parameter/Variable	Range	Condition
o_M	$\in (\tilde{o}_M, 1)$	Lemma 1
w_M	$> \tilde{w}_M$	
u_L	$\in (\tilde{u}_L, 1)$	Lemma 2
w_L	$> \tilde{w}_L$	
ξ	$< \tilde{\xi}$	Lemma 3

coordination of wage formation (Siebert, 1997).

4 The General Equilibrium Solution

In this section we present the general equilibrium comparative static analysis. The approach we choose is the following: First, we derive the changes from the initial equilibrium induced by an *infra-marginal change of the labour force due to migration*. We then give the intuitive interpretation of the results followed by a summary of the general equilibrium repercussions on the over-qualification and unemployment rates as well as on the relative wages.

4.1 A theoretical assessment without capital input

Following the standard approach pursued by Jones (1965), the comparative static analysis can be assessed by means of log-linearization to denote changes from the initial equilibrium, i.e. $\hat{x} = \ln\left(\frac{x+dx}{x}\right) \simeq dx/x$.

By the *Le Chatelier–Samuelson* principle, ignoring capital will only affect the results quantitatively, but not in qualitative terms, see Felbermayr & Kohler (2007). For that reason, and for convenience, we simplify the analysis by setting $\nu = \eta = 0$, and thus reducing the model to a two-factor production function with labour as the only input factor.

To begin with, take the total differentiation of the log-difference of the labour demand functions (6a) and (6b), (7a) and (7b), to obtain

$$\hat{w}_H - \hat{w}_M = \hat{M} - \hat{H}_m \tag{25.1}$$

$$\hat{w}_H - \hat{w}_L = \hat{L} - \hat{H}_s \tag{25.2}$$

Linearising the equilibrium conditions for the low- and medium-skilled labour markets, $L = (1-u_L)N_L + o_M N_M$ and $M = (1-o_M)N_M$, as well as the market

clearing condition for the high-skilled labour, yield

$$\hat{L} = l(\hat{N}_L - \bar{u}_L\hat{u}_L) + (1-l)(\hat{N}_M + \hat{o}_M) \tag{25.3}$$

$$\hat{M} = (\hat{N}_M - \bar{o}_M\hat{o}_M) \tag{25.4}$$

$$\hat{N}_H = h\hat{H}_m + (1-h)\hat{H}_s \tag{25.5}$$

where $\bar{u}_L = \frac{u_L}{1-u_L}$, $\bar{o}_M = \frac{o_M}{1-o_M}$, and $h = \frac{H_m}{N_H}$. Note that changes in the low-skilled employment are weighted by $l = \frac{(1-u_L)N_L}{L}$. Similarly, log-linearisation of the wage curves (18) and (22), yield

$$\hat{w}_M - \hat{w}_L = \varepsilon_m\hat{o}_M \tag{25.6}$$

$$\hat{w}_L - \hat{w}_M = \varepsilon_s\hat{u}_L \tag{25.7}$$

where $\varepsilon_m = -\frac{\bar{\lambda}_m}{o_M}\Phi(\cdot)$ and $\varepsilon_s = -\frac{\bar{\lambda}_s}{\xi\kappa u_L}\Psi(\cdot)$ denote the wage curve elasticities. From the price-setting definitions (11a) and (11b) we obtain

$$\hat{P}_m = (\alpha\hat{w}_H + (1-\alpha)\hat{w}_M) \tag{25.8}$$

$$\hat{P}_s = (\beta\hat{w}_H + (1-\beta)\hat{w}_L) \tag{25.9}$$

Log-linearisation of the intermediate goods demand equations, (2a) and (2b), yields

$$\hat{Y}_m = \hat{X} - \theta\hat{P}_m \tag{25.10}$$

$$\hat{Y}_s = \hat{X} - \theta\hat{P}_s \tag{25.11}$$

Changes in the total output can, then, be determined by log-linearising (1) which yields

$$\hat{X} = \varphi_x\hat{Y}_m + (1-\varphi_x)\hat{Y}_s \tag{25.12}$$

with $\varphi_x = \gamma\left(\frac{Y_m}{X}\right)^{\sigma_x} = \frac{P_mY_m}{X}$ denoting the share of Y_m in X. Finally, log-linearising the production functions (3a) and (3b), respectively, yields

$$\hat{Y}_m = \alpha\hat{H}_m + (1-\alpha)\hat{M} \tag{25.13}$$

$$\hat{Y}_s = \beta\hat{H}_s + (1-\beta)\hat{L} \tag{25.14}$$

This system of fourteen equations, (25.1)-(25.14), allows for the assessment of the general equilibrium effects on the fourteen endogenous variables $\hat{X}, \hat{Y}_m, \hat{Y}_s, \hat{P}_m, \hat{P}_s, \hat{H}_m, \hat{H}_s, \hat{M}, \hat{L}, \hat{o}_M, \hat{u}_L, \hat{w}_H, \hat{w}_M, \hat{w}_L$.

4.2 Comparative static analysis

In this section we examine the impact of an exogenous increase in the labour supply, which we attribute to immigration in each of the labour markets of our model. Particularly, we are interested in the repercussions on the low- and medium-skilled labour markets and on output. Intuitively, the wage-setting mechanism reveals that any exogenous increase in the labour endowments worsening (or improving) the labour market condition for one of the unionised labour, *ceteris paribus*, has also consequences for the other unionised labour. This is due to the fact that an increase in o_M (or u_L) will force the unions for wag restraint. Therefore, the wage linkage between both medium- and low-skilled unionised workers, resulting from the double bargaining mechanism as well as the endogenous unemployment benefits, implies that the outside option of the other unionised labour market will be affected too. Note that the bumping down effect has an additional direct impact on the low-skilled wages as u_L increases, see Eq. (19).

Accounting for the general equilibrium repercussions, however, we find that the wage restraint behaviour induces a higher labour demand for that type of labour. This is accompanied by changes in the allocation of high-skilled labour across the sectors as well as in the demand for goods due to goods price effects. As we show below, the crucial factor that determines the qualitative impact of migration reveals to be the factor cost share of the high-skilled labour. In what follows, we omit the formal proofs and provide instead the economic intuition of the results.[14].

The first interesting outcome of the analysis regarding changes in the wages as well as in unemployment and over-qualification rates is the following

Proposition 2. *A proportional* 10% *increase in supply of all three skill groups is consistent with almost no change in the wages as well as in over-qualification and unemployment rates.*

This is a standard result as the proportional increase of the labour force implies a scale effect and thus more resources are available in the economy to utilize (Dustmann et al., 2008). Note, however, that the marginal productivity of labour, the high-skilled labour reallocation, the output expansion of both sectors all depend on the size of $(\alpha - \beta)$, as we show below when discussing migration of each type of labour separately. Intuitively, for similar cost shares of the high-skilled labour across the two sectors, i.e. $(\alpha - \beta) \to 0$, both sectors

[14] A full formal derivation of the general equilibrium comparative static analysis is beyond the scope of this paper, and is therefore given in an extra appendix which can be provided upon request.

expand symmetrically due to proportional changes in the production costs, or alternatively in the marginal productivity, and thus inducing constant relative goods prices. Therefore, X, Y_m, Y_s, L and M all increase approximately proportionally. As shown in the last column of Table 4, the impact of migration of any skill group on X is always positive. Thus, setting $\hat{X} = 0$ does not affect the results qualitatively, and allows for a better exposition of the driving forces behind the immigration effects.

Next, we discuss the qualitative effects of an exogenous shock of each of the skill groups separately on low- and medium-skilled labour markets. An alternative way to demonstrate the effects on the unemployment and over-qualification rates is to reduce the system of equations derived in the previous section and to solve it for $\hat{o}_M$ and $\hat{u}_L$. In doing so, we obtain the following expressions[15]

$$\hat{o}_M = \frac{(\theta-1)\theta}{\zeta}(\beta-\alpha)\hat{w}_H - \frac{(\beta+\theta(1-\beta))-(\alpha+\theta(1-\alpha))(1-l)}{\zeta}\hat{N}_M + \frac{(\alpha+\theta(1-\alpha))l}{\zeta}\hat{N}_L \tag{26}$$

$$\hat{u}_L = -\varkappa\hat{o}_M \tag{27}$$

where ζ is a negative constant and $\varkappa = \frac{\varepsilon_m}{\varepsilon_s} > 0$. These two equations can be utilized to illustrate the role of the high-skilled cost shares (α, β), and to analyse the effects of different migration flows.

Table 4: Comparative Static Results

		$\hat{w}_H$	$\hat{w}_M$	$\hat{w}_L$	$\hat{o}_M$	$\hat{u}_L$	$\hat{X}$
$\hat{N}_H$	$\beta > \alpha$	$-$	$+$	$+$	$+$	$-$	$+$
	$\beta = \alpha$				0	0	
	$\beta < \alpha$				$-$	$+$	
$\hat{N}_M$	$\beta > \alpha$	$+$	$-$	$-$	$+/-$	$-/+$	$+$
	$\beta = \alpha$				$+$	$-$	
	$\beta < \alpha$				$+$	$-$	
$\hat{N}_L$		$+$	$-$	$-$	$-$	$+$	$+$

Assume first the scenario where only high-skilled immigration is allowed, i.e. $\hat{N}_H > 0 = \hat{N}_M = \hat{N}_L$. Unambiguously, the Walrasian nature of the high-skilled labour market induces a decline in $\hat{w}_H$. The labour market implication

[15]The derivation can be worked out as follows: equalize (25.13) and (25.10) as well as (25.14) and (25.11) to eliminate $\hat{Y}_m$ and $\hat{Y}_s$. Then, solve (25.1) and (25.2) for $\hat{H}_m$ and $\hat{H}_s$, respectively, and substitute them in the previously obtained equations. We then obtain two equations which can be solved for $\hat{w}_M$ and $\hat{w}_L$. Utilizing them in Eq. (25.6) and making use of (25.3) and (25.4), then after rearranging we obtain Eq. (26).

for the other two skill groups reduces, therefore, to the coefficient of w_H in (26). However, the crucial assumption that characterizes this coefficient is the following. As pointed out by Hamermesh (1993), in a two factor model the inverse of the elasticity of substitution is called the *elasticity of complementarity* indicating the percentage change in factor prices due to a 1 percent change in relative inputs. It denotes how factor prices that a representative firm must pay respond to an exogenous change in factor supply. Using a Cobb-Douglas function implies that both elasticities of substitution and of complementarity equal unity. On the other hand, the goods demand functions show to what extent demand for the two goods will adjust for changes in the goods prices which is determined by the parameter θ. Thus, in our setting, the labour substitution effect within each of the two major sectors is always dominated by the goods demand effect, i.e. $\theta > 1$. This relation is shown in the numerator of the $\hat{w}_H$ coefficient in Eq. (26).[16] The results are summarized in the next proposition.

Proposition 3. *If the economy is characterized by a Cobb-Douglas technology and* $1 - 1/\theta > 0$*, then high-skilled migration has*

i) *a neutral impact on both low- and medium-skilled labour markets for all* $\alpha \approx \beta$

ii) *a positive (negative) effect on the low (medium)-skilled labour market for all* $\alpha < \beta$*, and vice versa.*

The intuition is the following. It is clear that the right-hand-side of (26) reduces to the coefficient of w_H. As mentioned above, due to the complementarity effect both $\hat{w}_L$ and $\hat{w}_M$ increase. However, the relative increase depends on the size of the high-skilled cost share in each sector. The complementarity effect, for example, will be stronger in the manufacturing sector, for all $\alpha > \beta$, as the marginal productivity of medium-skilled workers rises relatively stronger than of low-skilled workers - or alternatively, we could argue that manufacturing firms experience a stronger decline in the production costs relative to the firms in the service sector. As goods prices are endogenous, the relative manufacturing goods price declines inducing a favourable shift in the demand for manufacturing goods, and thus, to a reallocation of high-skilled labour towards that sector. However, in the service sector the demand for low-skilled labour increases accompanied by a decline in u_L and an increase in o_M. This can be verified from the coefficient of w_H in (26). The opposite result for $\alpha < \beta$ follows by analogy. These effects are illustrated in the first five columns of Table 4 related to the impact of high-skilled migration ($\hat{N}_H$).

[16] See Felbermayr & Kohler (2007) for the case of CES production functions.

The assessment of only medium-skilled migration, i.e. $\hat{N}_M > 0 = \hat{N}_H = \hat{N}_L$, leads to the following results

Proposition 4. *Immigration of only medium-skilled workers has a negative effect on both medium- and low-skilled wages, a positive effect on the over-qualification rate, but a negative impact on the low-skilled unemployment.*

In this case, the right-hand-side of (26) reduces to the two first expressions on the RHS. It is straightforward that the high-skilled wage rate increases due to the complementarity effect. Therefore, following the discussion above, we have to elaborate on the signs of the two coefficients. Assuming $(\alpha - \beta) \rightarrow 0$ the analysis reduces to the coefficient of $\hat{N}_M$ which will be then simply $-(\alpha+\theta(1-\alpha))l/\zeta$ with $\zeta < 0$. Thus, the medium-skilled labour market friction unambiguously increases which in turn indicates from (27) that $\hat{u}_L < 0$.[17] The intuition behind the increase in the over-qualification is that due to labour market frictions not all new arriving medium-skilled workers can be absorbed by the labour market. This can be verified from (25.4) where the medium-skilled labour demand grows less proportional to $\hat{N}_M$. Since, the bumping down effect induces in turn an increase in low-skilled unemployment, *ceteris paribus*, the unions in the service sector are forced for wage restraint inducing a decline in the low-skilled wage. However, lower wages induce an increase in the demand for low-skilled employment. On the other hand, the relative increase in the high-skilled wage rate due to the complementarity effect, induces firms to substitute for high-skilled labour in both sectors. The low-skilled labour demand effect is stronger so that the bumping down effect is dominated which is also verified by our numerical assessment. Thus, the decline in the low-skilled wage rate is mitigated by this effect.

This leads us to the second interesting observation where the relative wage effects are consistent with wage polarization. This can be simply verified from (25.6) where for $(\alpha - \beta) \rightarrow 0$, $\hat{o}_M > 0$ inducing $\hat{w}_M - \hat{w}_L < 0$. Similarly, it holds by utilizing (27). Obviously, it follows $\hat{w}_H - \hat{w}_M > 0$ from (25.1).

Proposition 5. *Medium-skilled immigration induces wage polarization.*

The discussion on the results of low-skilled immigration is based on similar argumentation. A summary of the results is presented in Table 4. As mentioned above, the Table also shows that total output will increase in all scenarios. The reason is obvious. A more interesting question is, however, whether output per capita will increase. To answer that question we will turn to the simulation results of the model, presented in next section.

[17] In the unlikely extreme where $(\alpha - \beta) \rightarrow -\infty$, we find $\hat{o}_M < 0 < \hat{u}_L$ inducing $(\hat{w}_M - \hat{w}_L) > 0$.

5 Numerical assessment

To simulate the model, we use the EUKLEMS database to calibrate the parameter values which is presented in Appendix A. We use the calibrated parameters and benchmark values of the variables to simulate the impact of migration on output and the labour market.

5.1 Migration scenarios

Similarly to Felbermayr & Kohler (2007), we simulate migration scenarios for different skill compositions of migration flows. Table 5 gives an overview of our simulation scenarios.

Table 5: Simulation scenarios

Scenario	Description
(I)	Perfectly balanced immigration
(II)	Inflow at tails
(III)	Inflow of medium- and high-skilled
(IV)	High-skilled inflow only
(V)	Medium-skilled inflow only
(VI)	Low-skilled inflow only

In scenario (I), we assume a proportional increase in all skill levels which resembles approximately the Dutch immigration scenario, see Muysken & Ziesemer (2011). In scenario (II) we assume immigration to be composed of 75% low-skilled and 25% high-skilled labour. As pointed out by Felbermayr & Kohler (2007), this denotes the most realistic case for the past in the OECD countries, as it features bimodality in migration flows with a bias towards low-skilled migration. We also simulate the model for the current migration pattern within the EU (scenario (III)) where the majority of migrants from new member states (Poland and Baltic states) are predominantly young with medium- or high skill levels (Blanchflower et al., 2007). In doing so, we use as a benchmark the relative share of high-skilled foreign labour force in the U.S. which can be seen as a target value and subtract from that the value for Germany.[18] We, then, compute the percentage inflows such that the overall size of inflows equals 10% of the total labour force.[19] The resulting inflow consists

[18] As used in the migration literature, see Ziesemer (2011), we take the Worldbank data on migration stocks which provide information by educational attainment of immigrants and total labour force. However, the Worldbank data set provides only information for 1975 to 2000 which we use as a proxy.

[19] The computation is as follows: the share of high-skilled immigrants in the U.S. labour

for 44.3% of high skilled workers and the remaining part, 55.7%, is medium skilled. We also assess the quantitative impact of each skill groups separately in the scenarios (IV)-(VI). Furthermore, to ensure comparability between the different cases and due to the fact that just under 10% of the German workforce are foreign born, all scenarios are specified such that the overall size of the inflow is approximately 10% of the initial labour force. Finally, we assume a full adjustment of capital stock. Hence, the results indicate long-run effects.

5.2 Simulation results

The effect of various migration inflows is shown in Table 6. Interestingly, a perfectly balanced migration flow has a neutral impact on the receiving economy. This is mainly due to the linear homogeneity nature of the production functions and full capital adjustments which verifies the results of the theoretical part (Section 4.2). Migration flow at the tails of the skill distribution (scenario II) has mild positive wage effects for low- and medium-skilled labour, while high-skilled labour is hurt slightly. The labour market conditions of medium-skilled workers improve significantly while low-skilled unemployment risk is increased slightly. Deterioration in the relative commodity prices induces favourable demand shift for service goods and thus triggers relatively more high-skilled towards that sector. We see that the one-skill-type migration policy (scenarios (IV)-(VI)) reflect perfectly the predictions of the model discussed in the theoretical part. Therefore, changes in commodity prices (P_m, P_s) due to changes in factor prices (w_H, w_M, w_L) have significant effects on the reallocation of the mobile labour and on the labour market outcomes of the sector-specific labour. Looking at the welfare effects by means of GDP per head, we obtain the widely observed results where high-skilled migration (scenario IV) is unambiguously beneficial for the receiving country reflected in an increase of GDP per capita by 9% whereas low-skilled migration (scenario VI) might indeed be harmful, a decline of GDP per capita by 2%. However, with respect to medium-skilled migration (scenario V), the result implies a neutral impact as denoted by the overall increase of GDP per capita by almost 10%. Moreover, the impact on the relative medium-skilled wage rate shows the polarization effect confirming our hypothesis that the rise in medium-skilled migration might partly explain this phenomenon.

Finally, the most plausible scenario of a migration flow at the higher skill

force is about 10.91% and in the German labour force about 6.48% in 2000 which makes a difference of 4.43%. Therefore, in scenario (III) the high-skilled labour force has to rise by $44.30\% = 4.43\% \times (N/N_H)$ which gives us a total increase in medium-skilled labour force by $8.80\% = (10\% - 4.43\%) \times (N/N_M)$.

Table 6: Simulation of labour market effects of migration

% changes in	Variables	(I)	(II)	(III)	(IV)	(V)	(VI)
Labour supply	$\hat{N}_H$	10.00	11.13	44.3	100.00	0.00	0.00
	$\hat{N}_M$	10.00	0.00	8.80	0.00	15.88	0.00
	$\hat{N}_L$	10.00	33.39	0.00	0.00	0.00	37.04
Relative wages	$\hat{w}_H - \hat{w}_M$	0.00	−2.84	−37.24	−98.86	11.81	9.05
	$\hat{w}_L - \hat{w}_M$	0.00	−0.743	0.48	0.72	0.28	−0.91
Over-qual. rate	$\hat{o}_M$	0.00	−5.38	3.43	5.24	2.00	−6.61
Unempl. rate	$\hat{u}_L$	0.00	0.60	−0.39	−0.59	−0.22	0.74
Employment							
Medium	$\hat{M}$	10.00	7.12	4.25	−6.95	13.23	8.76
Low	$\hat{L}$	10.00	9.44	7.57	3.27	11.04	10.07
Reallocation	$\hat{H}_m$	10.00	9.97	41.50	91.91	1.41	−0.29
	$\hat{H}_s$	10.00	11.54	45.29	102.86	−0.50	0.10
Capital	$\hat{K}_m$	10.00	8.06	11.08	11.47	10.83	7.52
accumulation	$\hat{K}_s$	10.00	9.63	14.88	22.42	8.93	7.91
Prices	$\hat{P}_m$	0.00	0.37	0.89	2.57	−0.44	0.09
	$\hat{P}_s$	0.00	−0.15	−0.37	−1.08	0.19	−0.04
Output	$\hat{Y}_m$	10.00	7.69	10.19	8.90	11.28	7.43
	$\hat{Y}_s$	10.00	9.78	15.25	23.50	8.74	7.95
	$\hat{X}$	10.00	9.17	13.75	19.19	9.49	7.80

Notes: Scenario (I) has, actually, an asymmetric impact. That is, expansion of service sector is slightly stronger than of manufacturing, e.g. $\hat{Y}_s = 10.000103$ and $\hat{Y}_m = 10.000088$. This is due to the fact that the high-skilled shares are not identical. Subtracting 10% from the output values reveals the per capita values.

distribution (scenario III), which is dominated by medium skilled workers, has a positive welfare effect as per capita income rises by 3.75%. This induces us to conclude that overall medium skilled immigration might generate a positive economic outcome.

6 Concluding remarks

In this paper we present a theoretical model motivated by our stylized facts with two major (manufacturing and services) sectors and heterogeneous labour markets (high, medium, and low skills) to analyse the impact of various skill composition of immigration. While the impact of migration flows with different skills on the sectoral decomposition, goods prices and labour market outcomes

for the receiving country has been analysed separately, to our knowledge, no paper exists that examines the impact of immigration in a general equilibrium framework combining low-skill unemployment and medium-skill over-qualification in conjunction with endogenous goods prices. At the same time, the existing literature has paid less attention to the repercussions of medium-skill immigration considering simultaneously its impact on over-qualification and unemployment. Our stylized facts highlight the importance of this specific skill group and the analytical solution of the model verifies that it is able to reproduce these stylized facts. We elaborate the labour market as well as the GDP impacts of different migration scenarios. The following outcomes are at the core of our analysis.

First, the wage linkage at the lower level of the skill distribution (low and medium) owing to wage bargaining and endogenous unemployment benefits prevent the crowding-out effect of low-skilled workers induced by a supply shock of medium-skilled workers. In particular, medium skill immigration boosts the labour market of the low-skilled labour. At the same time, the wage linkage causes the wage compression between low and medium skills which is consistent with the cross-firm evidence for Germany. Second, our framework indicates that the recent wage "polarization" effect might be partly explained by the relative increase in the supply of medium-skilled labour.

Third, even under the assumption of perfectly elastic capital, a perfectly balanced immigration flow (i.e. matching the skill distribution of natives) can generate changes in wages and employment, due to the sectoral decomposition induced by endogenous goods prices. We show that this outcome depends crucially on the sectoral intensity of the mobile factor (here the high-skilled labour).

Using data for Germany, we quantify the impact of different immigration scenarios. In line with the common conclusion regarding the effect of skilled and unskilled, we also find that high-skilled immigration is beneficial for the receiving economy (increasing the GDP per capita by more than 9%), whereas low-skilled immigration is harmful (a decline in GDP per capita by more than 3%). Focusing on the medium-skilled immigration, we find new insights that augment the current findings in the literature. The results reveal, indeed, that immigration of medium-skilled labour can generate favourable economic outcomes. Beside improving the labour market conditions for low-skilled labour it also increases total output to the increase of the labour force, indicating a neutral impact. Moreover, simulating the recent migration pattern (medium- and high-skilled) in the course of EU enlargement reveals an improvement by 3.75% in per capita income.

Furthermore, the endogenous goods prices resulting from the price-setting behaviour are the important economic mechanism in explaining the substitutability between different type of labour. Our findings reveal that labour migration has a productivity effect for the firms by lowering the production costs. This in turn explains the changes in the skill intensity across the sectors which in the case of the Cobb-Douglas technology is essentially determined by the relative high-skilled cost shares across the sectors. Moreover, the neutral impact of medium-skilled migration gives an important insight for policy design regarding migration policies to satisfy the future labour replacement demand, for instance, due to ageing.

A Benchmark statistics and calibration

In order to provide a numerical solution of the model, we match the theoretical model with the data for a certain period. In doing so, we define values for the production side such as the input shares as well as for variables and parameters of our designed labour market like unemployment and over-qualification rates. Our exogenous parameters are $(\alpha, \beta, \nu, \eta, \sigma_x, \theta, \kappa, \xi, \delta_m, \delta_s, \lambda_m, \lambda_s)$. The endogenous variables are $(H_m, H_s, M, L, u_L, o_M,\ w_H, w_M, w_L, l, h, Y_m, Y_s, P_m, P_s)$ with the following exogenous variables (N_H, N_M, N_L). We compute the values mostly from the EUKLEMS database.[20] We also use when necessary different sources to obtain the values for the specific labour market parameters and variables. Table 7 provides an overview of the calibrated and benchmark equilibrium values. Note, in order to have the best-fit of the model with the data, we define the cost shares of the specific input factors simply as the sum of low- and med-skilled workers cost shares in each sector. Table 8 summarizes further the labour market benchmark values.

[20] For an extensive description of the data and the calibration approach, we refer the reader to the working paper version which will be provided upon request.

Table 7: Calibrated and benchmark equilibrium values for the industries

Description	Parameter/Variable	Value
Manuf. value-add (in 1000 Euros)$^{(a)}$	$P_m Y_m$	583,191
Service value-add (in 1000 Euros)$^{(a)}$	$P_s Y_s$	1,393,790
High-skilled labour force (in 1000 persons)$^{(a)}$	N_H	3870
Med-skilled labour force (in 1000 persons)$^{(a)}$	N_M	24043
Low-skilled labour force (in 1000 persons)$^{(a)}$	N_L	10092
Total labour force	$N = N_H + N_M + N_L$	38005
Unemployment rate$^{(b)}$	u_L	0.156
Manuf. capital cost share$^{(a)}$	ν	0.27
Manuf. high-skilled cost share$^{(a)}$	α	0.11
Manuf. med-skilled cost share$^{(a)}$	$1 - \alpha - \nu$	0.62
Serv. capital cost share$^{(a)}$	η	0.38
Serv. high-skilled cost share$^{(a)}$	β	0.13
Serv. low-skilled cost share$^{(a)}$	$1 - \beta - \eta$	0.49
Elasticity of Substitution$^{(c)}$	$\theta = \frac{1}{1-\sigma_x}$	4
	σ_x	0.75

(a) Computed from EUKLEMS data base.
(b) From OECD (2007, Table II.A1.1), denoting 2003-2004 average.
(c) From Abraham, Konings & Vanromelingen (2009).

Table 8: Labour market benchmark values

Description	Parameter/Variable	Value
Over-qualification rate$^{(d)}$	o_M	0.57
Manuf. high-skilled empl. (in 1000)$^{(e)}$	H_m	1012
Serv. high-skilled empl. (in 1000)	$H_s = N_H - H_m$	2859
	$h = \frac{H_m}{N_H}$	0.26
Med-skilled empl. (in 1000)	$M = (1 - o_M)N_M$	10339
Low-skilled empl. (in 1000)	$L = (1 - u_L)N_L + o_M N_M$	22223
	$l = (1 - u_L)N_L/L$	0.38
High-skilled wage rate$^{(f)}$	$w_H = \alpha P_m Y_m / H_m$	63.38
Med-skilled wage rate$^{(f)}$	$w_M = (1 - \alpha - \nu)P_m Y_m / M$	34.97
Low-skilled wage rate$^{(f)}$	$w_L = (1 - \beta - \eta)P_s Y_s / L$	30.73
Manuf. trade union bargaining power$^{(g)}$	δ_m	0.137
	λ_m	0.0743
Serv. trade union bargaining power$^{(h)}$	δ_s	0.087
	λ_s	0.0658
Proportionate factor$^{(i)}$	ξ	0.565
Weighting factor$^{(j)}$	κ	0.50
Manuf. wage curve	$\Phi(\cdot) = \frac{w_M}{w_L}$	1.14
Service wage curve	$\Psi(\cdot) = \frac{w_L}{w_M}$	0.88
Elasticity manuf. wage curve	$\varepsilon_{o_M} = -\frac{\partial \log \Phi(\cdot)}{\partial \log o_M} = -\frac{\lambda_m}{1+\lambda_m}\frac{1}{o_M}\Phi(\cdot)$	-0.14
Elasticity serv. wage curve	$\varepsilon_{u_L} = -\frac{\partial \log \Psi(\cdot)}{\partial \log u_L} = -\frac{\lambda_s}{1+\lambda_s}\frac{1}{\xi\kappa u_L}\Psi(\cdot)$	-1.23

(d) Calibrated to ensure $w_H > w_M > w_L > b$.
(e) Calibration is based on the condition $\alpha\frac{P_m Y_m}{H_m} = w_H = \beta\frac{P_s Y_s}{N_H - H_m}$.
(f) Calibration is based on the EUKLEMS data.
(g) Calibrated from the manufacturing wage-setting curve (18) and (15a).
(h) Calibrated from the manufacturing wage-setting curve (22) and (15b).
(i) Assumed.
(j) Assumed.

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