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A specific-factors approach

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Migration, Unemployment, and Skill Downgrading: A Specific-Factors Approach

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Abstract

This paper analyzes the impact of the skill composition of migration flows on the host country's labor market in a specific factors two-sector model with heterogeneous labor (low-, medium-, and highly-skilled) and price- and wage-setting behavior. The low- and medium-skilled labor markets are characterized by frictions due to wage bargaining. Moreover, we assume skill downgrading of unemployed medium-skilled workers into low-skilled labor supply. Endogenous benefits create an interdependency between the two bargaining processes. Particular attention is paid to medium-skilled migration, which enables us to contribute to the literature by replicating important stylized facts regarding medium skills, such as i) the interaction between immigration, low-skilled unemployment, and medium-skill downgrading, ii) the increase in low skill intensive service jobs. The model is calibrated using data for Germany. The key findings are: (i) a migration-induced supply shock of medium skilled workers decreases the low-skilled unemployment rate under endogenous benefits; (ii) migration of only medium skilled labor has a neutral impact on GDP per capita; (iii) immigration of medium skilled labor together with some high skilled labor has a positive effect on output per capita.

Zusammenfassung

Dieses Papier analysiert die Arbeitsmarktauswirkungen der Qualifikationsstruktur der Migrationsströme. Dazu wird ein Zwei-Sektoren Modell mit spezifischen Faktoren, heterogenen Arbeitsmärkten (gering-, mittel- und hochqualifiziert) und Preis- und Lohnfestsetzung verwendet. Die Arbeitsmärkte der gering- und mittelqualifizierten Fachkräfte sind von Friktionen geprägt, welche auf die Tarifverhandlungen zurückzuführen sind. Darüber hinaus wird die Annahme getroffen, dass mittelqualifizierte Arbeitslose in den Arbeitsmarkt der geringqualifizierten herabgestuft werden können. Der Fokus liegt insbesondere auf Migration von mittelqualifizierten Fachkräften, welcher uns ermöglicht die Literatur zu ergänzen und wichtige stilisierten Fakten bezüglich des mittleren Qualifikationsniveaus zu reproduzieren, wie zum Beispiel i) die Interaktion zwischen Migration, geringqualifizierte Arbeitslose und die Herabstufung von mittelqualifizierten Arbeitnehmern, ii) der Zuwachs von niedrigqualifizierten Arbeitsplätze im Dienstleistungssektor. Das Modell, kalibriert mit Hilfe der Datensätze für Deutschland, liefert folgende wichtige Ergebnisse: (i) ein durch Migration herbeigeführter Angebotsschock von mittelqualifizierten Fachkräften verringert die Arbeitslosenquote der niedrigqualifizierten Arbeitskräfte, wenn die Arbeitslosenhilfe endogen bestimmt ist; (ii) die Migration von nur mittelqualifizierten Fachkräften hat eine neutrale Auswirkung auf das BIP pro Kopf; (iii) die Zuwanderung von mittel- und hochqualifizierten Arbeitskräften hat einen positiven Effekt auf das BIP pro Kopf.

JEL classification: F22; J51; J52; J61; J64

Keywords: Medium-Skilled Migration; Wage and Price Setting; Specific Factors Model; Unemployment; Skill Downgrading

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1 Introduction

The migration pattern in Europe has significantly changed over the last decades, driven by the integration of national markets into global markets as well as the soaring demand for better educated, highly skilled workers due to an intensified international competition. In general, the overall stock of immigrants with higher educational attainments has increased significantly. Indeed, the East–West immigration patterns in the course of the enlargement of the EU[1] in the past decades have seen a substantial increase in the supply of medium skilled (i.e., with upper secondary education) immigrants.[2]

On the other hand, looking at the labor market outcomes of immigrants, one considerable friction becomes evident. Immigrants face a substantial risk of job–skill mismatches. Several recent studies have found that immigrants with higher educational levels, especially those who moved in the course of the Eastern EU-enlargement, have been relegated to jobs which require a lower educational/skill attainment—indicating a skill downgrading in occupations.[3] In an empirical cross-country analysis Brynin and Longhi (2009) find that the incidence of skill downgrading is more pronounced among workers at the middle of the skill distribution.

Therefore, these observations emphasize on the one hand an immigration-induced shift in the labor supply of better educated workers over the last decade. On the other hand, the immigration-driven rise in skill downgrading offers a rationale for potential displacement effects of the least skilled native workers.[4] The objective of this paper is to revisit the labor market effects of immigration by assessing the relation between skill downgrading and unemployment in a general equilibrium framework. Intuitively, higher skill downgrading due to the immigration of better educated workers should induce a substitution effect for the least skilled workers, thus displacing them from the labor market.

However, as we elaborate below, in special institutional settings, an immigration-induced rise in skill downgrading generates a decline in the low skilled unemployment rate—indicating a complementarity effect. The rationale behind this effect is given by the endogenous outside option for the displaced least skilled workers. Endogenizing the unemployment benefits of these displaced workers makes them more responsive to economic shocks.

There exists a vast literature examining various channels of immigration-induced economic and distributional effects on the host country. One strand of the literature focuses

1 This refers to the entry of eight Central Eastern European countries (CEECs) and two Mediterranean countries into the EU on May 2004.

2 See Kahanec and Zimmermann (2010) for a survey of recent migration patterns in the EU and Blanchflower et al. (2007) for recent patterns in the UK.

3 See Drinkwater et al. (2009); Dustmann et al. (2013) for recent evidence in the UK. For example, Dustmann et al. (2013) empirically assess the immigration effect along the wage distribution. Although the newly arrived immigrants to the UK have on average higher educational attainments, the authors find that they are located at the lower end of the wage distribution—evidencing a skill downgrading effect. For cross-country evidence, see OECD (2007).

4 Several recent studies have shown that, in general, attitudes towards immigration are heterogeneous across native population and depend on the labor market situations, welfare considerations, and non-economic factors (see, for example, Dustmann and Preston, 2007; Dustmann et al., 2008; Facchini and Mayda, 2008; Mayda, 2006). See also Boeri and Brücker (2005) for a discussion of concerns regarding "welfare shopping".

on labor market effects through adjustment channels such as changes in wages and (un)employment through which native workers are potentially directly affected.[5] In spite of an overall negligible effect of immigration on wages and employment, the findings of these studies, using the canonical (multi-nested production technology) model, emphasize the role of factors such as changes in the skill structure, substitutability between natives and immigrants, and the elasticity of the capital supply. For example, the easier the substitutability becomes, the larger the burden is for native workers, while a perfectly elastic capital supply induces the so-called "immigration surplus" (Borjas, 1995; Dustmann et al., 2008).[6] However, these studies assume implicitly that all newly arrived immigrants are perfectly integrated in the labor market according to their skill level, i.e., no skill–job mismatch. We address this omission and supplement this strand of the literature by assessing the impact of immigration on skill downgrading and unemployment. Furthermore, we elaborate the interaction between these two friction variables together with sectoral composition effects driven by endogenous manufacturing prices under different labor market institutional regimes.

Another strand in the literature emphasizes different (indirect) adjustment mechanisms such as changes in the output mix (sectoral composition) and manufacturing prices through which immigrants are absorbed by the host economy.[7] The overall conclusion is that in a small open economy where manufacturing prices are determined by international markets, immigration flows generate a Rybczynski-type of effect, indicating the insensitivity of wages to immigration. In particular, the recent empirical evidence, focusing on local industry-labor markets, highlights that immigration induces a technology or intensity effect, i.e., an increase in the relative use of the enhanced factor in the production process, and to some extent a scale effect, i.e., a relative expansion of output/firms using immigrants (or factors with similar characteristics) more intensively (González and Ortega, 2011; Dustmann and Glitz, 2012; Lewis, 2003).[8] We contribute to this literature by incorporating simultaneously these different adjustment mechanisms when examining the impact of immigration on skill downgrading and unemployment under the endogenous unemployment benefit scheme.

A recent development that has received a lot of attention emphasizes substantial changes in the structure of occupations in many advanced countries. This observation reveals a significant increase in low paid service jobs over the last decade indicating a shift in the labor demand. The literature examining the driving force behind this phenomenon emphasizes the role of progress in information and communication technology (ICT), replacing

[5] Important early contributions are Card (1990); Borjas (1995); Borjas et al. (1996) as well as recent contributions by Borjas (2003); Ottaviano and Peri (2008, 2011) for the US; recent important studies on the German labor market are Brücker and Jahn (2011); D'Amuri et al. (2010); Dustmann et al. (2009); Felbermayr et al. (2010); on the UK labor market Dustmann et al. (2008); Manacorda et al. (2011); Dustmann et al. (2005); as well as the cross-country evidence for UK, Germany and Denmark by Brücker et al. (2012).

[6] The main conclusion of these recent studies 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.

[7] See recent contributions by Cortes (2008); Dustmann and Glitz (2012); Felbermayr and Kohler (2006, 2007); González and Ortega (2011); Lewis (2003).

[8] Dustmann and Glitz (2012) emphasize further the role of newly created firms, explaining 18 percent of the overall adjustment to migration-induced labor supply shocks. The authors also find significant negative wage effects for the non-traded sector.

workers by machines and computers, as the main driving force behind this development.[9] As emphasized by Autor and Dorn (2013), consumer preferences play an important role in explaining this rise in service jobs. If consumers favor variety over specialization in consumption, then an unbalanced-biased technology progress raises the aggregate demand for service output—a phenomenon also known as the Baumol (1967)'s disease.[10]

We incorporate this implication in our general equilibrium framework but with two distinct differences from Autor and Dorn (2013). First, in our framework, the labor market is characterized by frictions where medium skilled workers face the risk of being downgraded into low-paid, service jobs, while low skilled workers end up in unemployment. Second, assuming a more general functional form in the service sector, we show that the rise in the demand for aggregate service output is not necessarily associated with higher demand for labor in that sector. In fact, it depends on the interaction between consumer preferences, i.e., the substitutability between different consumption goods, and production technology, i.e., the substitutability between input factors in the production process, especially in the service sector.

An interesting finding of this paper is that the immigration of medium skilled workers can generate a similar result to that resulting from advances in technology, regarding the increase in low paid service jobs due to the incidence of skill downgrading. To our knowledge, this is a new insight which has not been addressed in the literature. Moreover, our model enables us to address different adjustment channels, such as shifts in relative labor demand, taking into account the "substitution effect" between different input factors, as well as shifts in the labor supply, taking into account the "crowding-out effect", under different labor market regimes.

To offer an integrated explanation of the above observations, we develop a two-sector ("manufacturing" and "services") model with heterogeneous workers. We assume that low skilled workers are employed in the services sector whereas medium skilled workers are employed mainly in the manufacturing sector. Finally, a common and perfectly mobile factor, such as highly skilled labor, is employed in both sectors. In line with the institutional labor market setting in many European countries, we assume a standard collective bargaining approach: a right-to-manage bargaining model. We also assume that medium skilled workers who do not find a job in the manufacturing sector have the outside option to take a low paid job in the services sector, while low skilled workers not finding a job in the services sector end up in unemployment. We then examine numerically the general equilibrium effects of an infra-marginal (i.e., a discontinuous jump) increase in the labor force due to immigration. In general, our model, calibrated to the German economy, generates three interesting predictions:

- Due to endogenous unemployment benefits, a migration-induced supply of medium

[9] This phenomenon is also known as the "polarization" phenomenon, implying a relative change against occupation at the middle range of the skill distribution that can be easily computerized. See Acemoglu and Autor (2011) for a survey of recent important contributions.

[10] Generally, the hypothesis claims that unbalanced technical progress in sectors with high TFP growth, such as manufacturing, will also induce a rise in employment/wages in sectors with low TFP growth, like services.

skilled workers generates a complementarity effect boosting the employment of low skilled workers.[11]

- A stronger substitutability in consumption relative to that of factors in the services and manufacturing sectors, together with endogenous manufacturing prices and unemployment benefits, generate an expansion of low skilled intensive labor input in the service sector due to an immigration-induced supply shock of medium skilled labor.

- Immigration of medium and high skilled workers generates beneficial economic effects by increasing the output per capita.[12]

We are, therefore, able to contribute to the literature by replicating important stylized facts regarding changes in labor market institutions as well as recent patterns in immigration, particularly of the medium skilled, and the employment structure discussed in the next section.

The set up of the paper is as follows. The next section presents the stylized facts on migration patterns, on the relation between low skilled unemployment and the skill downgrading of medium skilled workers, and trends in employment for the major Wester European destination countries. In Section 3 we exposit the theoretical framework with two major sectors, three skill groups, and a double wage bargaining model determining the wages of medium- and low-skilled labor. In Section 4, we first provide a qualitative assessment of a comparative static analysis for two different labor market regimes, derived by means of log-linearization 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 some concluding remarks.

2 Stylized facts

As mentioned above, over the last two decades there has been a substantial improvement in the educational attainments of immigrants: a shift towards the middle and upper range of the skill distribution. Table 1 highlights this feature for the major Western European destination countries. It is noticeable that over the last two decades in all countries the share of the immigrant population with lower educational attainments has considerably declined. Moreover, the educational attainments of immigrants from the New Member States[13] (NMS) joining the European Union in 2004 possess a similar pattern, constituting a supply shock of better educated workers. In addition, Brücker et al. (2012) highlight in their recent empirical study that medium skilled workers make up a major part of the immigrant as well as the native labor force in Germany and Denmark.

[11] See also Beladi (1990), who shows that the accumulation of a specific factor can increase the total employment in an unemployment-plagued economy. However, he neither incorporates manufacturing price effects nor a heterogeneous labor force.

[12] See also Storesletten (2000) who find a beneficial fiscal effect for medium and high skilled immigration scenario using generational accounting.

[13] These are the following countries: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia.

Table 1: Educational attainment of immigrants in selected countries of destination

Country	All Immigrants						Immigrants from NMS					
	Shares in 2010			Percentage changes 1995-2010			Shares in 2010			Percentage changes 1995-2010		
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Austria	37.4%	45.9%	16.7%	-13.2%	3.5%	33.0%	24.9%	56.1%	19.0%	-6.1%	-3.1%	22.0%
Denmark	49.2%	28.8%	21.9%	-9.9%	6.9%	13.2%	53.7%	25.7%	20.5%	27.1%	-22.2%	-16.6%
France	80.5%	7.5%	11.9%	-20.1%	73.2%	89.5%	46.1%	20.9%	33.0%	-38.7%	91.2%	136.6%
Germany	53.1%	30.5%	16.4%	-17.5%	13.1%	32.3%	21.7%	49.1%	29.2%	-15.2%	3.4%	8.4%
Ireland	45.0%	21.0%	34.0%	-42.0%	14.8%	46.4%	31.9%	34.2%	34.0%	-13.9%	45.9%	-14.2%
Netherlands	63.2%	19.5%	17.3%	-28.8%	50.1%	48.7%	44.9%	29.4%	25.8%	-29.0%	50.4%	49.3%
Spain	32.7%	46.3%	21.0%	-41.2%	18.3%	23.8%	19.2%	54.7%	26.1%	-41.2%	18.3%	23.8%
Sweden	43.4%	36.1%	20.5%	-27.4%	-2.3%	62.2%	24.4%	38.2%	37.5%	-29.9%	0.9%	36.5%
UK	57.1%	16.9%	26.0%	-23.9%	-54.9%	88.3%	51.5%	9.2%	39.3%	-9.8%	-45.9%	51.4%

Source: Brücker et al. (2013).
Notes: The educational levels are defined as follows: Low = ISCED 0-2, Medium = ISCED 3-4, High = ISCED 5-6. The data denotes the shares in immigrants population above 25 years.

It is documented in OECD (2007) that the labor market performance of immigrants across many advanced countries has stronger mismatches than do natives, indicating a higher incidence of skill downgrading. Empirical studies reveal that a significant and increasing proportion of low-skill jobs are nowadays carried out by better educated, overqualified workers—see Borghans and de Grip (2000) and Hartog (2000) for an overview of these studies. Recent studies on post EU-enlargement have provided further evidence. For example, Drinkwater et al. (2009) analyze the performance of Polish immigrants in the UK labor market and find that the majority of them are employed in low-skill and low paid jobs despite having relatively high levels of education. Moreover, a recent study by Brynin and Longhi (2009) finds, using household survey data, an excess of skill downgrading at the medium-skilled level (i.e., with upper secondary schooling) which contributes almost one-half of all overqualified persons.

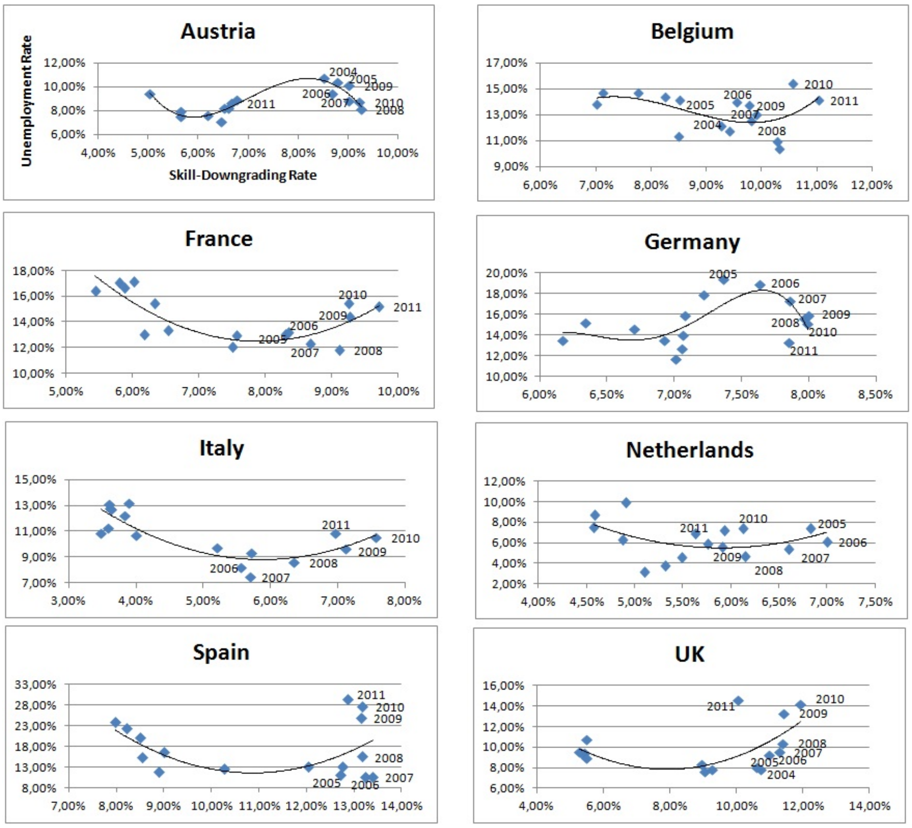
These stylized facts suggest that the rise in low skilled unemployment would not only be the result of a relative demand shift driven by technology progress, but also the consequence of a relative supply shift which leads to a “crowding-out” of low skilled workers, as has also been observed by Pierrard and Sneessens (2003).

Figure 1 depicts the interaction between changes in the low-skilled unemployment rate and the skill downgrading rate of medium skilled workers for a selected group of European countries. It is readily evident that, except for Germany (to some degree also for Austria), in all other European countries there is a hand in hand movement between unemployment and skill downgrading rates in recent years.[14] What explains this exception? We believe that this pattern could be partly explained by changes in the labor market institution with the objective of making the labor market, especially for low skilled workers, more flexible. In fact, Germany has experienced substantial labor market reforms—the so-called *Hartz* reforms[15]—affecting considerably the outside option of workers, i.e., unemployment ben-

[14] The Netherlands is an exceptional in our sample, where the medium skill downgrading rate has successively declined over the last years.

[15] The Hartz reforms were introduced in several steps started in 2002. However, the reform introduced in 2005, known as Hartz IV, which has been seen as the most controversial one, refers to the integration of unemployment assistance schemes into the social welfare scheme.

Figure 1: Correlation between low skilled unemployment rate and medium skilled downgrading rate



Source: Eurostat.
Notes: The medium skilled downgrading rate denotes the proportion of medium skilled workers, i.e. those according to ISCED 3-4, in low skill intensive jobs defined according to ISCO 9. The fitted line designates a polynomial curve of degree 2, 3 or 4.

efits. As we elaborate below, endogenizing unemployment benefits can partly reflect the different labor market outcomes driven by changes in the labor market institutions across the countries. In addition, it is noticeable that in almost all countries the skill downgrading rate has risen over the last years.

Finally, as mentioned earlier, the recent empirical evidence verifies a contraction of medium skill intensive occupations in many advanced countries—cf. Goos et al. (2011) for recent evidence in Europe. Interestingly, looking at the disaggregated skill-occupation level, the share of low- and medium-skilled workers employed in the lowest paying occupations, mostly services, has substantially increased over the last decades. Table 2 exhibits this trend and highlights the skill downgrading of medium skilled workers.

We summarize these stylized facts as follows.

1. The proportion of medium skilled workers has substantially increased in many European countries over the last years.
2. Both low- and medium-skilled employment has strongly risen in low paid service jobs.
3. Medium skilled labor has a higher incidence of skill downgrading.

Table 2: Evolution of employment in Europe, by educational attainment and occupations

Country	Lowest paid occupations		Middling occupations		Highest paid occupations	
	Shares in 1996	Percentage point change 1996-2011	Shares in 1996	Percentage point change 1996-2011	Shares in 1996	Percentage point change 1996-2011
A: Low skilled workers						
Austria	33.84%	13.29	53.01%	-11.08	12.86%	-2.21
Belgium	30.93%	11.73	53.37%	-8.45	14.02%	-2.34
Denmark	49.77%	4.53	39.80%	-9.25	8.53%	6.20
France	30.94%	14.75	52.83%	-16.80	15.12%	2.44
Germany	33.00%	14.20	48.23%	-9.16	15.57%	-4.07
Italy	35.13%	3.60	56.54%	-5.23	7.36%	1.80
Netherlands	29.55%	15.56	45.88%	-7.32	17.87%	-3.24
Spain	35.17%	15.59	52.57%	-11.29	12.09%	-4.57
UK	34.67%	7.83	42.73%	-7.97	21.65%	0.11
B: Medium skilled workers						
Austria	19.95%	6.84	50.61%	-10.44	29.09%	3.72
Belgium	21.70%	9.84	50.24%	-7.53	26.55%	-1.60
Denmark	26.36%	7.07	48.52%	-12.49	24.26%	5.88
France	19.19%	12.64	52.47%	-16.44	26.36%	4.32
Germany	19.31%	7.38	49.77%	-6.32	28.97%	-0.61
Italy	17.28%	7.36	42.98%	-5.12	38.72%	-2.60
Netherlands	19.14%	11.19	33.53%	-2.72	43.19%	-5.95
Spain	27.32%	15.84	43.18%	-6.36	28.19%	-9.02
UK	19.68%	15.27	50.18%	-17.57	28.88%	3.01
C: High skilled workers						
Austria	4.59%	2.73	17.40%	-1.11	77.98%	-1.78
Belgium	3.75%	2.02	18.19%	-1.96	77.53%	0.01
Denmark	4.60%	2.16	9.92%	-3.34	84.58%	1.75
France	2.50%	5.80	11.46%	0.19	85.30%	-6.05
Germany	5.63%	0.71	18.72%	-11.75	74.57%	11.23
Italy	3.82%	2.70	8.77%	3.87	87.07%	-6.88
Netherlands	4.76%	2.44	8.75%	-0.19	83.78%	-1.44
Spain	9.22%	4.10	23.32%	-1.48	66.82%	-2.44
UK	5.49%	7.19	12.93%	-1.60	80.70%	-5.20

Source: Eurostat, own calculations.
Notes: Employment shares are based on total employment, excluding armed force occupations. The occupation classified according to 'ISCO 0' is omitted. Following Goos et al. (2011), we define the three occupation groups at 1-digit ISCO level as follows: Lowest paid occupations = ISCO 5 & 9; middling occupations = ISCO 4, 6, 7 & 8; highest paid occupations = ISCO 1, 2 & 3.

4. The relation between skill downgrading and low-skilled unemployment rates could be partly explained by changes in the unemployment benefits scheme.

In the next section, we discuss the properties of the theoretical framework, followed by a comparative static analysis.

3 The theoretical framework

We consider a model economy described by two sectors ($j = m, s$) that produce two different consumption products, *manufacturing* and *services*. Both sectors use one common and one specific factor. The common factor is competitively supplied and perfectly mobile between the two sectors. To get a better idea, we define the common factor as the highly skilled labor and denote it by H_j.[16] The sector-specific factors are two distinct labor inputs: medium skilled workers (l_M) supply labor to the manufacturing sector and low skilled workers (l_L) to the services sector.[17]

Goods are produced by combining H_m and the medium skilled labor input l_M using the following constant returns to scale (CRS) technology.

$$Y_m = f_m(l_M, H_m) = \left[\alpha\left(l_M\right)^{\frac{\sigma_m - 1}{\sigma_m}} + (1-\alpha)\left(H_m\right)^{\frac{\sigma_m - 1}{\sigma_m}}\right]^{\frac{\sigma_m}{\sigma_m - 1}} \qquad (1)$$

Here, $\sigma_m \in [0, 1]$ denotes the elasticity of substitution between the input factors in the manufacturing sector, and $\alpha \in (0, 1)$ is a distribution parameter. In the other sector, services are produced by combining H_s and the low skilled labor input l_L using the technology

$$Y_s = f_s(l_L, H_s) = \left[\beta\left(l_L\right)^{\frac{\sigma_s - 1}{\sigma_s}} + (1-\beta)\left(H_s\right)^{\frac{\sigma_s - 1}{\sigma_s}}\right]^{\frac{\sigma_s}{\sigma_s - 1}}, \qquad (2)$$

where $\sigma_s \in [0, 1]$ denotes the elasticity of substitution in the service sector, and $\beta \in (0, 1)$ is a distribution parameter.

To close the model, we define the domestic demand for both goods as follows. The total domestic consumption is defined by a CES technology

$$X = \left(Y_m^{\frac{\sigma_x - 1}{\sigma_x}} + Y_s^{\frac{\sigma_x - 1}{\sigma_x}}\right)^{\frac{\sigma_x}{\sigma_x - 1}} \qquad (3)$$

where the planner maximizes the gross domestic product X subject to the budget constraint while taking the manufacturing and service prices (P_m, P_s) as given. Formally, this can be written as

$$\max_{Y_m, Y_s} \left(Y_m^{\frac{\sigma_x - 1}{\sigma_x}} + Y_s^{\frac{\sigma_x - 1}{\sigma_x}}\right)^{\frac{\sigma_x}{\sigma_x - 1}}, \text{ s.t. } P_m Y_m + P_s Y_s = X,$$

[16] To keep the analysis tractable we do not introduce for the moment physical capital explicitly in our analysis. However, under the assumption that physical capital moves freely between countries (at least in the case of advanced countries), including it in the analysis will cause a level effect due to the Le Chatelier–Samuelson principle (Neary, 1985; Felbermayr and Kohler, 2007). Therefore, the results of the analysis are not affected in qualitative terms.

[17] These input factors could be interpreted as a type of job/occupation intensively used in each sector. In the literature, they are referred to as ‘routine’ and ‘manual’ jobs, respectively, see Autor and Dorn (2013). Our intention is, however, to capture the overall changes in the employment structure by educational level. Thus, we disregard a detailed discussion of the matching process of workers to occupation, and refer interested readers to Autor and Dorn (2013) and the references therein.

where $\sigma_x \in [0,1]$ denotes the elasticity of substitution in consumption. We take the price of X as numeraire in the remaining part of the analysis. Consequently, all variables are defined in real terms and we assume no inflation. The solution to the optimization problem yields the following domestic demand functions.

$$Y_m = XP_m^{-\sigma_x} \tag{4a}$$

$$Y_s = XP_s^{-\sigma_x} \tag{4b}$$

3.1 The producer's optimization problem

After incurring a fixed cost, a representative firm chooses the optimal demand for inputs by minimizing its (variable) production cost, taking the factor prices as given. Formally, the minimized cost function is

$$C_j^*(w_i, w_H, Y_j) = \min_{l_i, H_j} \{w_i l_i + w_H H_j : f_j(\cdot) - Y_j \leq 0\}, \text{ for } i = \{L, M\}, j = \{m, s\}$$

and the corresponding minimized cost functions are

$$C_m^*(w_M, w_H, Y_m) = \left[\alpha^{\sigma_m} (w_M)^{1-\sigma_m} + (1-\alpha)^{\sigma_m} (w_H)^{1-\sigma_m}\right]^{\frac{1}{1-\sigma_m}} Y_m \tag{5a}$$

$$C_s^*(w_L, w_H, Y_s) = \left[\beta^{\sigma_s} (w_L)^{1-\sigma_s} + (1-\beta)^{\sigma_s} (w_H)^{1-\sigma_s}\right]^{\frac{1}{1-\sigma_s}} Y_s. \tag{5b}$$

Now, by Shepards's Lemma, we obtain the optimal factor demands in each sector. In the manufacturing sector this implies

$$\frac{\partial C_m^*(\cdot)}{\partial w_M} = \alpha^{\sigma_m} \left(\frac{c_m(\cdot)}{w_M}\right)^{\sigma_m} Y_m = l_M \tag{6a}$$

$$\frac{\partial C_m^*(\cdot)}{\partial w_H} = (1-\alpha)^{\sigma_m} \left(\frac{c_m(\cdot)}{w_H}\right)^{\sigma_m} Y_m = H_m, \tag{6b}$$

and in the service sector

$$\frac{\partial C_s^*(\cdot)}{\partial w_L} = \beta^{\sigma_s} \left(\frac{c_s(\cdot)}{w_L}\right)^{\sigma_s} Y_s = l_M \tag{7a}$$

$$\frac{\partial C_s^*(\cdot)}{\partial w_H} = (1-\beta)^{\sigma_s} \left(\frac{c_s(\cdot)}{w_H}\right)^{\sigma_s} Y_s = H_s, \tag{7b}$$

where the unit costs are denoted by $c_j(\cdot)$, the term within the square brackets of Eqs. (5).

In the next step, the representative firm in each sector maximizes the flow profit (i.e., net of fixed costs) subject to the domestic demand function.[18] Formally, this can be written as

$$\max_{Y_j} \{P_j Y_j - C_j^*(\cdot, Y_j)\}, \text{ for } j = \{m, s\},$$

[18] Having only one firm in each sector is consistent with free entry if fixed costs are sufficiently high to make the entry of a second firm unprofitable, see Cahuc and Zylberberg (2004: Ch. 7) for a general discussion.

subject respectively to (4a), (4b), (5a), (5b). The solution yields the standard mark-up pricing behaviour

$$P_m = \frac{1}{\rho} c_m(w_M, w_H) \tag{8a}$$

$$P_s = \frac{1}{\rho} c_m(w_L, w_H) \tag{8b}$$

with $\rho = \frac{\sigma_x - 1}{\sigma_x} \in [0, 1]$. We now turn to the characteristics of the labor market.

3.2 Wage setting and labor market frictions

Taking into account the institutions of the European labor market and the empirical findings on low wage differentials between low- and medium-skilled workers in unionized firms (Dustmann and Schönberg, 2009), we assume union coverage in the low- and medium-skilled labor markets. That is, both types of workers are represented by two different labor unions who bargain their wages. There is, thus, an elastic institutional wage curve, reflecting the labor supply curve for the two skill groups as well as explaining the source of the labor market frictions. In particular, the wage setting mechanism induces a skill downgrading for some medium skilled workers. Those workers who do not find a job in the manufacturing sector have the outside option to take a service job. For the low skilled workers who do not find a job in the service sector, the outside option is unemployment.

Following Booth (1995) and Layard et al. (2005), wages are determined by the *right-to-manage* bargaining solution, i.e., the negotiating parties only bargain over the wages, whereas the optimal employment decisions are 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, which allows us to neglect firm–union specific indices (cf. Koskela and Stenbacka, 2009, 2010).

At optimum, the firm's net gain is simply the flow of profits (Π), i.e., net of fixed costs. The net gain for the labor union is simply the net result of the bargained wage and the outside option. Thus, the objective function of the labor unions in the manufacturing and service sectors, respectively, is given by

$$\begin{aligned} U_m &= (w_M - \bar{w}_M) l_M \\ U_s &= (w_L - \bar{w}_L) l_L \end{aligned}$$

where $\bar{w}_i, \forall i = \{L, M\}$ denotes the reference wage which is taken as given by each labor union.

The medium- and low-skilled wages are the result of the following maximization problem subject, respectively, to the labor demand equations, (6a) and (7a)

$$\max_{w_i} \{((w_i - \bar{w}_i) l_i)^{\delta_j} \Pi_j^{1-\delta_j}\}, \text{ for } i = \{L, M\}, j = \{m, s\},$$

where δ denotes the bargaining strength of the labor union. The solution of the wage bargaining yields the standard wage mark-up behavior[19]

$$w_i = (1+\lambda_i)\bar{w}_i, \tag{9}$$

$$\lambda_i = \frac{\delta_j}{(\sigma_x - 1)\theta_i + \delta_j(1-\theta_i)(\sigma_j - 1)}, \text{ for } i = \{L, M\}, j = \{m, s\}. \tag{10}$$

where $\theta_i = \frac{w_i l_i}{w_i l_i + w_H H_j}$ denotes the cost share of the labor input.

In keeping with the stylized facts, we assume that medium skilled workers face the risk of holding a low skill job in the services sector when they cannot find employment in the manufacturing sector. We define the skill-downgrading rate of medium skilled workers as

$$d_M = 1 - \frac{l_M}{N_M}, \tag{11}$$

with N_M the total medium skilled labor force.

The reference wage of a medium skilled worker ($\bar{w}_M$) then is

$$\bar{w}_M = (1-d_M)w_M + d_M w_L. \tag{12}$$

Substituting this expression into (9) and rearranging, we obtain the wage curve of medium skilled workers (WC_M) in the manufacturing sector,

$$w_M = \Phi(\lambda_m, d_M) w_L, \tag{13}$$

where $\Phi(\lambda_m, d_M) = \frac{(1+\lambda_m)d_M}{1-(1+\lambda_m)(1-d_M)} > 1$ with the following properties: $\frac{\partial\Phi(\cdot)}{\partial\delta_m} > 0$ and $\frac{\partial\Phi(\cdot)}{\partial d_M} < 0$. Thus, a higher bargaining power and or level of employment yield stronger outside options for the union. In addition, any exogenous shock will induce a shift in (13) due to changes in w_L, and also induce a change in the shape of the wage curve due to changes in d_M.

In a similar way, the institutional wage curve for the low skilled workers in the service sector can be derived. Since the outside option for these workers is unemployment, the reference wage of a low skilled worker can be defined as

$$\bar{w}_L = (1-u_L)w_L + u_L B_L, \tag{14}$$

where B_L denotes the unemployment benefit and u_L is the unemployment rate and is defined by[20]

$$u_L = 1 - \frac{l_L - d_M N_M}{N_L}, \tag{15}$$

[19] We refer the reader to Appendix B for the derivation.

[20] The collective bargaining agreements are, in almost all EU countries, made at the industry level, see Venn (2009: Table 1) for an overview. Generally, a collective agreement between the labor union and the employers' association in one sector applies also to other firms in the same sector. However, it is less likely that cross-repercussions or the collective agreement in one sector would be recognized by other parties in other sectors. Thus, we assume that during the bargaining process, the labor union in the service sector does not take into account the crowding-out effect when negotiating over the low skilled wage.

where N_L denotes the total low skilled labor force.

Substituting (14) into the bargaining solution in the service sector (9) and rearranging yields the institutional wage curve (WC_L) of low skilled workers in the service sector:

$$w_L = \Psi(\lambda_s, u_L) B_L, \tag{16}$$

where $\Psi(\lambda_s, u_L) = \frac{(1+\lambda_s)u_L}{1-(1+\lambda_s)(1-u_L)} > 1$ with the following properties: $\frac{\partial\Psi(\cdot)}{\partial\delta_s} > 0$ and $\frac{\partial\Psi(\cdot)}{\partial u_L} < 0$. Changes in the wage curve (16) and thus the labor market outcomes of the low skilled workers depend on the characteristics of the unemployment benefits scheme. For example, under an exogenous unemployment benefits scheme, i.e., keeping the outside option of low skilled workers fixed, exogenous shocks induce only changes in the elasticity of the wage curve (16), while under an endogenous benefit scheme, the wage curve will also shift as in (13). In the next section, we elaborate on the labor market implications for low and medium skilled workers under these two different benefit schemes.

Finally, let the total endowment of the mobile factor be

$$N_H = H_m + H_s. \tag{17}$$

To sum up, the equilibrium of the model is characterized by fourteen endogenous variables (X, Y_m, Y_s, P_m, P_s, d_M, u_L, l_M, l_L, H_m, H_s, w_M, w_L, and w_H) defined by Eqs. (1)–(4b), (7a)–(8b), (13), and (15)–(17).

4 The general equilibrium solution

In deriving the general equilibrium effects of exogenous changes in the labor supply due to immigration, we are particularly interested in the labor market reactions of low and medium skilled workers under two different labor market regimes: exogenous vs. endogenous unemployment benefits.[21]

4.1 Changes in the steady state

We pursue the standard approach by computing changes from the initial equilibrium by means of log-linearization (Jones, 1965), i.e. $\hat{x} = \ln\left(\frac{x+\mathrm{d}x}{x}\right) \cong \frac{\mathrm{d}x}{x}$.

We commence as follows. Differentiate totally the log-difference of the labor demand functions (6b) and (6a), (7b) and (7a), to obtain

$$\hat{l}_M - \hat{H}_m = -\sigma_m(\hat{w}_H - \hat{w}_M) \tag{17.1}$$

$$\hat{l}_L - \hat{H}_s = -\sigma_s(\hat{w}_H - \hat{w}_L) \tag{17.2}$$

[21] Also note that when computing the general equilibrium effect, we take the cost shares as given at the initial steady state, which is consistent with assuming a Cobb–Douglas production technology.

Taking the total domestic expenditure as given[22], i.e. $\hat{X} = 0$, then from optimal demand conditions (4a) and (4b), log-linearization yields

$$\hat{Y}_m = -\sigma_x \hat{P}_m \tag{17.3}$$

$$\hat{Y}_s = -\sigma_x \hat{P}_s \tag{17.4}$$

From the price-setting Eq's (8a) and (8b) we obtain

$$\hat{P}_m = \theta_M \hat{w}_M + (1-\theta_M)\hat{w}_H \tag{17.5}$$

$$\hat{P}_s = \theta_L \hat{w}_L + (1-\theta_L)\hat{w}_H \tag{17.6}$$

Next, let the share of low-skilled workers in the total employment of low skilled service jobs be $s_L = \frac{(1-u_L)N_L}{l_L}$ and define the share of the mobile factor in total employment working in the goods sector as $h = \frac{H_m}{N_H}$, then log-linearizing the labor market equilibrium conditions (11), (15), and the market clearing condition for the mobile factor (17), we obtain

$$\hat{l}_M = (\hat{N}_M - \bar{d}_M \hat{d}_M) \tag{17.7}$$

$$\hat{l}_L = s_L(\hat{N}_L - \bar{u}_L \hat{u}_L) + (1-s_L)(\hat{N}_M + \hat{d}_M) \tag{17.8}$$

$$\hat{N}_z = h\hat{H}_m + (1-h)\hat{H}_s \tag{17.9}$$

Thus, changes in the low-skilled employment are weighted at the initial shares s_L.

Similarly, log-linearization of the wage curves (13) and (16), yields

$$\hat{w}_M = \varepsilon_M \hat{d}_M + \hat{w}_L \tag{17.10}$$

$$\hat{w}_L = \varepsilon_L \hat{u}_L + \hat{B}_L \tag{17.11}$$

where $\varepsilon_M = -\frac{\partial \Phi(\cdot)}{\partial d_M}\frac{d_M}{\Phi(\cdot)}$ and $\varepsilon_L = -\frac{\partial \Psi(\cdot)}{\partial u_L}\frac{u_L}{\Psi(\cdot)}$ denote the wage curve elasticities.

Finally, log-linearizing the production functions (1) and (2), yields

$$\hat{Y}_m = \theta_M \hat{l}_M + (1-\theta_M)\hat{H}_m \tag{17.12}$$

$$\hat{Y}_s = \theta_L \hat{l}_L + (1-\theta_L)\hat{H}_s \tag{17.13}$$

The general equilibrium effects is described by a system of thirteen Eqs. (17.1)-(17.13) for the thirteen endogenous variables $\hat{Y}_m, \hat{Y}_s, \hat{P}_m, \hat{P}_s, \hat{H}_m, \hat{H}_s, \hat{l}_M, \hat{l}_L, \hat{d}_M, \hat{u}_L, \hat{w}_H, \hat{w}_M, \hat{w}_L$.

4.2 Comparative statics with exogenous benefits

Since we are interested in changes in the two friction variables, medium skill downgrading and low skill unemployment rates, the system derived above can be reduced and solved

[22] A rationale for this assumption could be the result of macroeconomic policies seeking to keep a balanced national account, see Felbermayr and Kohler (2007) for a similar argument.

for $\hat{d}_M$ and $\hat{u}_L$. Moreover, to highlight the complementarity and substitution effects under the two different institutional settings, we focus first on the increase in medium skill endowments and its impact on the labor market friction variables. Thus, for the moment $\hat{N}_L = \hat{N}_H = 0$. Also notice that the assumption of exogenous unemployment benefit implies $\hat{B}_L = 0$. In the next section we relax this assumption.

We commence with the consumption goods market clearing condition. From (17.3), (17.5), and (17.12), we obtain

$$\theta_M \hat{l}_M + (1-\theta_M)\hat{H}_m = -\sigma_x(\theta_M \hat{w}_M + (1-\theta_M)\hat{w}_H). \tag{17.3'}$$

Similarly, combining (17.4), (17.6), and (17.13), we get

$$\theta_L \hat{l}_L + (1-\theta_L)\hat{H}_s = -\sigma_x(\theta_L \hat{w}_L + (1-\theta_L)\hat{w}_H). \tag{17.4'}$$

Next, solve (17.1) and (17.2) w.r.t. the mobile factor and utilize, respectively, in (17.3') and (17.4') and rearrange to obtain

$$\hat{l}_M = \hat{w}_H(1-\theta_M)(\sigma_m - \sigma_x) - \hat{w}_M \Omega_m \tag{17.3''}$$
$$\hat{l}_L = \hat{w}_H(1-\theta_L)(\sigma_s - \sigma_x) - \hat{w}_L \Omega_s \tag{17.4''}$$

where $\Omega_j = (\theta_i \sigma_j + (1-\theta_i)\sigma_x) > 0$ for $j = \{m, s\}, i = \{L, M\}$, also interpreted in the literature as the *generalized* elasticity of substitution capturing both the elasticity in consumption and production (Jones, 1965).

Utilizing now the labor market condition (17.7) and (17.8) in (17.3'') and (17.4''), respectively, yields

$$(\hat{N}_M - \bar{d}_M \hat{d}_M) = \hat{w}_H(1-\theta_M)(\sigma_m - \sigma_x) - \hat{w}_M \Omega_m \tag{17.3'''}$$
$$-s_L \bar{u}_L \hat{u}_L + (1-s_L)(\hat{N}_M + \hat{d}_M) = \hat{w}_H(1-\theta_L)(\sigma_s - \sigma_x) - \hat{w}_L \Omega_s \tag{17.4'''}$$

To eliminate the wage rates $\hat{w}_M$ and $\hat{w}_L$, utilize (17.10) and (17.11) in (17.3''') and (17.4'''). Then, rearrange to obtain

$$\begin{aligned} \hat{N}_M - \bar{d}_M \hat{d}_M &= \hat{w}_H(1-\theta_M)(\sigma_m - \sigma_x) - (\varepsilon_M \hat{d}_M + \varepsilon_L \hat{u}_L)\Omega_m \\ -s_L \bar{u}_L \hat{u}_L + (1-s_L)(\hat{N}_M + \hat{d}_M) &= \hat{w}_H(1-\theta_L)(\sigma_s - \sigma_x) - \varepsilon_L \hat{u}_L \Omega_s \end{aligned}$$

Rearranging these two equations further, we derive two equations as a function of variables of interest[23]

$$\hat{d}_M = \frac{\hat{N}_M}{\mu_M} - \frac{\Omega_m \tilde{\varepsilon}_L}{\mu_M}\hat{u}_L - \frac{(1-\theta_M)(\sigma_m - \sigma_x)}{\mu_M}\hat{w}_H \tag{18a}$$
$$\hat{u}_L = \frac{(1-s_L)}{\mu_L}(\hat{N}_M + \hat{d}_M) - \frac{(1-\theta_L)(\sigma_s - \sigma_x)}{\mu_L}\hat{w}_H \tag{18b}$$

[23] It is important to notice that the equations in (18) contain a third endogenous variable, $\hat{w}_H$. Therefore, the system will be closed after utilizing the equilibrium labor market condition for the mobile factor, (17.9). However, changes in the factor price of the mobile factor are feedback effects and thus of second-order. To keep the results readable, we focus on the direct effect and provide the intuition behind changes in w_H.

where $\mu_M = (\bar{d}_M + \Omega_m \tilde{\varepsilon}_m) > 0$ and $\mu_L = (s_L \bar{u}_L + \Omega_s \tilde{\varepsilon}_L) > 0$ with $\tilde{\varepsilon}_i \equiv -\varepsilon_i > 0$ for $i = \{L, M\}$.

Now utilizing (18a) in (18b) and after some manipulation. we obtain

$$\frac{\hat{u}_L}{\hat{N}_M} = \frac{\Gamma}{\Upsilon} - \frac{\Lambda}{\Upsilon} \frac{\hat{w}_H}{\hat{N}_M} \tag{19}$$

where $\Gamma = \frac{\mu_M \mu_L + \Omega_m \tilde{\varepsilon}_L (1-s_L)}{\mu_M \mu_L} > 0$, $\Upsilon = \frac{(1-s_L)(1+\mu_M)}{\mu_M \mu_L} > 0$ and $\Lambda = \frac{(1-\theta_M)(1-s_L)(\sigma_m - \sigma_x) + (1-\theta_L)(\sigma_s - \sigma_x)\mu_L}{\mu_M \mu_L} \lessgtr 0$.[24] The first term on the right-hand side denotes the first-order effect of an immigration-induced increase in the medium skill endowment. It is readily seen that this effect is positive, indicating the substitution effect of low skilled workers caused by an increase in skill downgrading of medium skilled workers. The second term shows the feed back effect from factor price adjustments of the mobile factor. It is intuitively clear that the increase in medium skill endowments raises unambiguously the marginal productivity of the mobile factor inducing an increase in w_H, i.e. $\frac{\hat{w}_H}{\hat{N}_M} > 0$. However, the magnitude of substitutability in consumption relative to the one in production will determine the labor market outcomes of low and medium skill workers.

Now substitute (19) back into (18a) and rearrange to obtain

$$\frac{\hat{d}_M}{\hat{N}_M} = \left(\frac{1}{\mu_M} - \frac{\eta \Gamma}{\Upsilon}\right) + \left(\frac{\eta \Lambda}{\Upsilon} - \chi\right) \frac{\hat{w}_H}{\hat{N}_M} \tag{20}$$

where $\eta = \frac{\Omega_m \tilde{\varepsilon}_M}{\mu_M}$ and $\chi = \frac{(1-\theta_M)(\sigma_m - \sigma_x)}{\mu_M}$. Recalling the definitions of Γ and Υ below (19), then the right hand side in (20) can be further manipulated to obtain

$$\left(\frac{1}{\mu_M} - \frac{\eta \Gamma}{\Upsilon}\right) = \frac{s_L \bar{u}_L + \tilde{\varepsilon}_L (\Omega_s - \Omega_m)}{\mu_M \Upsilon}.$$

This expression denotes the direct effect of a supply shock of medium skill labor on the downgrading rate. The following proposition summarizes the main results.

Proposition 1 (Substitution effect under exogenous benefit)**.** *If the labor market of low and medium skilled workers is characterized by frictions, such that medium skilled workers' outside option is the low paid manual service job whereas low skilled workers end up in unemployment, then under exogenous unemployment benefit immigration of medium skilled workers will induce a substitution effect for the low skilled workers. Reallocation of the mobile factor as well as labor market outcomes of medium skilled workers depend crucially on the interaction between consumers preferences and the two production technologies. The stronger the substitutability is in the service sector ($\Omega_s > \Omega_m$), the more medium skilled workers are downgraded into the service sector.*

Intuitively, the mechanism of the adjustment process works as follows. The increase in the medium skilled labor supply induces a higher downgrading threat and thus lowers the

[24] The ambiguity of Λ is the result of two forces: substitutability in consumption versus substitutability in production. To make this more obvious, consider the following special case where both sectors use Cobb-Douglas technology, i.e. $\sigma_m = \sigma_s = 1$, while in consumption the assumption still holds $\sigma_x > 1$. It can be then easily shown that the numerator becomes unambiguously negative and simplifies to $-[(\sigma_x - 1)((1-\theta_M)(1-s_L) + (1-\theta_L)\mu_L)]$.

outside option of the medium skill labor union. The magnitude of the downward adjustment of medium skill wages depends on two forces. The elasticity of the medium skill wage curve as well as the substitutability in manufacturing production (σ_m). An elastic wage curve together with low substitutability in the manufacturing sector imply an increase in the skill downgrading rate due to lower downward wage adjustment.

From eq. (15) it is then immediately evident that the unemployment risk for the low skilled workers rises. To countervail this effect, the low skill labor union agrees upon downward wage adjustment. However, as in the manufacturing sector, wage adjustment depends on the substitutability between low skilled workers and the mobile factor in the service sector (σ_s) too. The interaction between these forces depends finally on consumers preferences, i.e. substitutability between service and manufacturing goods captured by σ_x. Since both goods prices are endogenous, changes in the factor prices lead to changes in the goods prices inducing shifts in goods demand. More precisely, medium skill immigration increases the marginal productivity of high skilled workers and with it their wage. Thus, the sector that utilizes more intensively the high skilled labor input experiences a relative increase in the production cost and thus in the relative goods price. Consequently, that sector experiences an unfavorable goods demand effect.

To get a better notion for the intuition, recall the special case where $\sigma_s = \sigma_m = 1$, i.e. Cobb-Douglas production technology, while the assumption regarding consumers preferences still holds, i.e. $\sigma_x > 1$. This simplifies the first expression on the right hand side in (20) to

$$\frac{s_L \bar{u}_L + \tilde{\varepsilon}_L[(\sigma_x\theta_L + (1-\theta_L)\sigma_s) - (\sigma_x\theta_M + (1-\theta_M)\sigma_m)]}{\mu_M \Upsilon} = \frac{s_L \bar{u}_L + \tilde{\varepsilon}_L(\theta_m - \theta_s)(\sigma_x - 1)}{\mu_M \Upsilon}.$$

Now, consider the case $\theta_M > \theta_L$. This implies that the service sector uses the mobile factor more intensively. This indicates a favorable shift in consumption for the manufacturing goods, inducing a relative stronger expansion of the manufacturing sector. This shift in consumption is also accompanied by a reallocation of the high skilled workers (mobile factor) into the manufacturing sector. However, due to the labor market imperfections for both low and medium skilled workers downward wage adjustments are rigid. Therefore, not all newly arrived medium skilled workers can be absorbed by the market such that $\mathrm{d}d_M >> 0$.

Summing up, the special case highlights the role of changes in the production cost structure under endogenous goods prices and when consumers prefer variety in consumption. Generally, the driving force is captured by the interaction between generalized elasticities indicating the substitutability in consumption and in production.[25] Moreover, immigration of medium skilled workers displaces some of the low skilled workers due to the relative higher labor market rigidity denoted by the exogenous unemployment benefit.

[25] Readers familiar with Autor and Dorn (2013) will recognize the main difference to our approach as the authors consider no substitutability in the service sector.

4.3 Comparative statics with endogenous benefits

We now relax this assumption of a fixed benefit and define instead the unemployment benefit as the proportion of the weighted average of medium and low skilled wage rates.[26] In doing so, the outside option of low skilled workers becomes endogenous and linked to the medium skilled wage rate. Therefore, changes in the medium skilled wage directly affect the low skilled labor market. As we show below, this definition of endogeneity generates a source of labor market flexibility for low skilled workers.[27]

Formally, we define the unemployment benefit as follows

$$B_L = \xi(\kappa w_M + (1-\kappa)w_L),$$

where $\xi, \kappa \in (0,1)$ denote, respectively, the proportionate and weighting parameters. Then, log-linearizing B_L yields

$$\hat{B}_L = \phi_M \hat{w}_M + (1-\phi_M)\hat{w}_L \tag{21}$$

where $0 < \phi_M = \frac{\xi\kappa w_M}{B_L} < 1$.

Substituting (21) in (17.11) and rearranging yields

$$\hat{w}_L = \frac{\varepsilon_L}{\phi_M}\hat{u}_L + \hat{w}_M \tag{17.11'}$$

Comparing (17.11') with (17.11), two differences become readily evident. First, the coefficient of $\hat{u}_L$ is now increased by ϕ_M. We interpret the parameter ϕ_M as the labor market policy parameter. That is, lowering ϕ_M, e.g. due to a decline in the proportionate parameter ξ, induces an increase in the elasticity of the wage curve, making the low skilled labor market more flexible. Thus, lower ϕ_M could be considered as the *Hartz IV* reforms introduced in Germany. The second difference is denoted by the fact that now the low skill wage curve is affected by changes in medium skilled wages. More precisely, changes in medium skilled wages induce a shift in the low skill wage curve. This interdependency creates an additional source of flexibility.

Similar to the fixed benefit regime, we solve the system for the two friction variables in order to obtain a similar structure as in the Eqs (18). We commence by solving (17.3''') and (17.4''') for $\hat{w}_M$ and $\hat{w}_L$, respectively, to obtain

$$\begin{aligned}
\hat{w}_M &= \frac{1}{\Omega_m}\left(\hat{w}_H(1-\theta_M)(\sigma_m-\sigma_x) - (\hat{N}_M - \bar{d}_M\hat{d}_M)\right)\\
\hat{w}_L &= \frac{1}{\Omega_s}\left(\hat{w}_H(1-\theta_L)(\sigma_s-\sigma_x) + \bar{u}_L s_L \hat{u}_L - (\hat{N}_M + \hat{d}_M)\right)
\end{aligned}$$

[26] Weiss and Garloff (2009) show that in most European countries the level of benefits, contrary to the Anglo-Saxon countries, adjusts on a yearly basis and it is closely tied to the per capita income. Also Dustmann and Schönberg (2009) show for Germany that the wage differential between low and medium skilled workers in unionized firms is lower compared to non-unionized firms.

[27] We provide in the supplementary Appendix B a formal discussion of the equilibrium properties of the two wage curves.

Subtracting the two equations yields

$$\hat{w}_M-\hat{w}_L=\frac{1}{\Omega_m}\left(\hat{w}_H(1-\theta_M)(\sigma_m-\sigma_x)-(\hat{N}_M-\bar{d}_M\hat{d}_M)\right)-\frac{1}{\Omega_s}\left(\hat{w}_H(1-\theta_L)(\sigma_s-\sigma_x)+\bar{u}_L s_L\hat{u}_L-(\hat{N}_M+\hat{d}_M)\right). \tag{22}$$

Furthermore, from (17.10) and (17.11') we get

$$\hat{w}_M-\hat{w}_L=-\tilde{\varepsilon}_M\hat{d}_M \tag{17.10'}$$

$$\hat{w}_M-\hat{w}_L=\frac{\tilde{\varepsilon}_L}{\phi_M}\hat{u}_L \tag{17.11''}$$

Substituting (17.10') for $(\hat{w}_M-\hat{w}_L)$ in (17.11'') and (22), and rearranging yields the following two equation system

$$\hat{d}_M=-\left(\tilde{\varepsilon}_M+\frac{\bar{d}_M}{\Omega_m}+\frac{(1-s_L)}{\Omega_s}\right)^{-1}\left[\left(\frac{1-s_L}{\Omega_s}-\frac{1}{\Omega_m}\right)\hat{N}_M+\left(\frac{(1-\theta_M)(\sigma_m-\sigma_x)}{\Omega_m}-\frac{(1-\theta_L)(\sigma_s-\sigma_x)}{\Omega_s}\right)\hat{w}_H-\frac{\bar{u}_L s_L}{\Omega_s}\hat{u}_L\right] \tag{23a}$$

$$\hat{u}_L=-\frac{\tilde{\varepsilon}_M}{\tilde{\varepsilon}_L}\phi_M\hat{d}_M \tag{23b}$$

Define for convenience the following expressions: $\upsilon=\left(\tilde{\varepsilon}_M+\frac{\bar{d}_M}{\Omega_m}+\frac{(1-s_L)}{\Omega_s}\right)>0$, $\Delta=\left(\frac{1-s_L}{\Omega_s}-\frac{1}{\Omega_m}\right)\lesseqgtr 0$, and $\Sigma=\left(\frac{(1-\theta_M)(\sigma_m-\sigma_x)}{\Omega_m}-\frac{(1-\theta_L)(\sigma_s-\sigma_x)}{\Omega_s}\right)=\left(\frac{\sigma_m}{\Omega_m}-\frac{\sigma_s}{\Omega_s}\right)\lesseqgtr 0$. Before proceeding, it might helpful to consider first the behavior of eq. (23b). The effect of an increase in skill downgrading on the low skill unemployment rate is mitigated by lowering ϕ_M. As already mentioned above, this is the result of a stronger responsiveness of the low skill wage curve to changes in the unemployment rate under the endogenous unemployment benefit scheme. However, to drive the full effect, we need to solve (23a) and (23b) for the two variables $\hat{d}_M$ and $\hat{u}_L$.

In doing so, combine (23a) and (23b) and dividing by $\hat{N}_M$, then after some rearranging we get

$$\frac{\hat{u}_L}{\hat{N}_M}=\frac{\tilde{\varepsilon}_M\phi_M}{\tilde{\varepsilon}_L\upsilon}\left[\Delta+\Sigma\frac{\hat{w}_H}{\hat{N}_M}-\frac{\bar{u}_L s_L}{\Omega_s}\frac{\hat{u}_L}{\hat{N}_M}\right]$$

$$\Rightarrow\frac{\hat{u}_L}{\hat{N}_M}=\left(\frac{\tilde{\varepsilon}_M\phi_M\Omega_s}{\tilde{\varepsilon}_M\phi_M\bar{u}_L s_L+\tilde{\varepsilon}_L\upsilon\Omega_s}\right)\Delta+\left(\frac{\tilde{\varepsilon}_M\phi_M\Omega_s\Sigma}{\tilde{\varepsilon}_M\phi_M\bar{u}_L s_L+\tilde{\varepsilon}_L\upsilon\Omega_s}\frac{\hat{w}_H}{\hat{N}_M}\right) \tag{24}$$

Dividing (23b) by $\hat{N}_M$ and utilizing (24) yields

$$\frac{\hat{d}_M}{\hat{N}_M}=-\left(\frac{\tilde{\varepsilon}_L\Omega_s}{\tilde{\varepsilon}_M\phi_M\bar{u}_L s_L+\tilde{\varepsilon}_L\upsilon\Omega_s}\right)\Delta-\left(\frac{\tilde{\varepsilon}_L\Omega_s\Sigma}{\tilde{\varepsilon}_M\phi_M\bar{u}_L s_L+\tilde{\varepsilon}_L\upsilon\Omega_s}\frac{\hat{w}_H}{\hat{N}_M}\right) \tag{25}$$

Equations (24) and (25) are the analogs to (19) and (20) derived previously under an exogenous benefit regime. Comparing the first terms on the right hand side in (24) and in (19) it becomes apparent that the direct effect in case of endogenous benefit regime is ambiguous and is determined by the term Δ. In Eq (19) under an exogenous benefit scheme, the sign of the first term is always positive. To verify the sign of the first term in (24), recall the definition of Δ, and utilize Ω_m and Ω_s defined earlier in eqs. (17.3'') and

(17.4''). It follows[28]

$$\Delta = \left(\frac{1-s_L}{\Omega_s} - \frac{1}{\Omega_m}\right) = -\frac{s_L}{\Omega_s} - \frac{\Omega_s - \Omega_m}{\Omega_m \Omega_s}, \quad (26)$$

which designates the sign of the direct effect of medium skill immigration on the skill downgrading rate. Next proposition summarizes the main results.

Proposition 2 (Complementarity effect under endogenous benefit)**.** *If low and medium skilled labor markets are characterized by frictions where labor supply is defined by an institutional wage setting curve, then for a stronger substitutability in the service sector, i.e. $\Omega_s > \Omega_m$, an immigration-induced increase in the medium skilled endowment raises the incidence of skill downgrading followed by a reduction in low skilled unemployment, implying a complementarity effect. In addition, the more flexible low skilled labor market (lower ϕ_M) is, the less severe is the adverse effect of higher incidence of skill downgrading.*

The intuition behind the driving force is similar to the one of Proposition 1, except that now due to the endogenous unemployment benefit, the low skilled labor market has become more flexible as indicated in Eq. (17.11'). Put differently, a higher risk of unemployment due to the migration-induced increase in skill downgrading implies a stronger downward wage adjustment for the low skilled workers. Therefore, a relative stronger substitutability in the service sector ($\Omega_s > \Omega_m$) induces an increase in the demand for the low skilled labor input in the service sector. This contrasts to the exogenous benefit scheme where the adjustment process was rather rigid. It, therefore, highlights the importance of labor market institutions.

This also provides the rationale behind the different patterns in the low skilled unemployment rate and the skill downgrading rate across the European countries over the recent years (Figure 1). That is, low skilled workers in countries like Germany that experienced substantial labor market reforms (reducing ϕ_M) are less vulnerable in terms of employment outcomes to exogenous shocks such as immigration. Formally, this can be shown as follows. Consider two identical countries, F and D, differing only in the policy parameter ϕ_M. Comparing the direct effect of medium skilled immigration on the low skilled unemployment rate, i.e. keeping the second term constant, yields

$$\left.\frac{\hat{u}_L^F}{\hat{N}_M}\right|_{\frac{\hat{w}_H}{\hat{N}_M}=0} \lesseqgtr \left.\frac{\hat{u}_L^D}{\hat{N}_M}\right|_{\frac{\hat{w}_H}{\hat{N}_M}=0}$$

$$\left(\frac{\tilde{\varepsilon}_M \phi_M^F \Omega_s}{\tilde{\varepsilon}_M \phi_M^F \bar{u}_L s_L + \tilde{\varepsilon}_L \upsilon \Omega_s}\right)\Delta \lesseqgtr \left(\frac{\tilde{\varepsilon}_M \phi_M^D \Omega_s}{\tilde{\varepsilon}_M \phi_M^D \bar{u}_L s_L + \tilde{\varepsilon}_L \upsilon \Omega_s}\right)\Delta$$

$$\phi_M^F \lesseqgtr \phi_M^D.$$

In conclusion, the comparative static analysis emphasizes two important findings. First, following the medium skilled immigration, the incidence of skill downgrading of medium

[28] To see the sign more clearly, it is worthwhile to look again at the special case where $\sigma_m = \sigma_s = 1$, while $\sigma_x > 1$. We then obtain $\Delta = \frac{-s_L}{\Omega_s} - \frac{(\sigma_x - 1)(\theta_m - \theta_s)}{\Omega_s \Omega_m} < 0$.

skilled workers together with a scheme of endogenous benefits induces an increase in low skilled employment in the service sector. This is in line with the stylized facts discussed earlier, about the pattern of immigration and employment composition in many advanced countries. Second, the production technology in the service sector is a crucial determinant explaining the labor market outcomes. This differs from the discussion of Autor and Dorn (2013), who emphasize only the roles of consumer preferences and of production technology in the goods sector. Moreover, it is worth pointing out that in the special case of a Cobb–Douglas production technology, the results are driven by the factor cost share, i.e., the factor intensity. In the next section we provide a quantitative assessment and examine the general equilibrium effects of different immigration scenarios.

5 Numerical assessment

To simulate the model, we use the EUKLEMS database to calibrate the parameter values for Germany. We take 2005 as the benchmark year. We then use the calibrated parameters and benchmark values of the variables to simulate the impact of migration on output and the labor market. In doing so, we modify the model by including physical and human capital input factors in the production function. Here we consider the special case of the production function, i.e. a Cobb-Douglas technology, while the assumption on consumption preferences ($\sigma_x > 1$) holds. Note that, as discussed above, in this case the results depend on the the cost shares (i.e., factor intensity) in both sectors. In Appendix A, we outline the model as well as the values of the benchmark parameters and variables.

5.1 Migration scenarios

Similarly to Felbermayr and Kohler (2007), we simulate migration scenarios for different skill compositions of migration flows. Table 3 gives an overview of our simulation scenarios.

Table 3: 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 approximately resembles the Dutch immigration scenario, see Muysken and Ziesemer (2011). In scenario (II), we assume the immigration to be composed of 75% low skilled and 25% highly skilled labor. As pointed out by Felbermayr and Kohler (2007), this denotes the most realistic case for the past in the OECD countries, as it models a 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 the new member states (Poland and the Baltic states) are predominantly young with medium or high levels of skill (Blanchflower et al., 2007). In doing so, we use as a benchmark the relative share of highly skilled foreign labor force in the U.S., which can be seen as a target value, and subtract from that the value for Germany.[29] We, then, compute the percentage inflows so that the overall size of the inflows equals 10% of the total labor force.[30] The resulting inflow consists of 44.3% of the highly skilled workers and the remaining part, 55.7%, is the medium-skilled.

We also assess the quantitative impact of each skill group 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 in such a way that the overall size of the inflow is approximately 10% of the initial labor force. Finally, we assume full adjustment of the capital stock. Hence, the results indicate long-run effects. It is also important to notice that the service sector is slightly more high skill intensive than the manufacturing sector.

5.2 Simulation results

The effect of various migration inflows is shown in Table 4. The first interesting result is summarized in the following proposition

Proposition 3. *A proportional 10% increase in supply of all three skill groups is consistent with no change in relative wages, unemployment rates, and skill downgrading.*

This is a standard result, since a proportional increase of the labor force implies a scale effect due to the full capital adjustments, confirming earlier empirical results (Dustmann et al., 2008). Our next result is summarized below

Proposition 4. *If the economy has labor market frictions so that there is a risk of skill downgrading, then the immigration of better educated workers induces an increase in low-skilled intensive jobs in the service sector as well as an expansion of the sector using that input factor more intensively.*

This effect is readily evident by looking at the immigration scenarios (III) , (IV), and (V). In all these scenarios, the employment level of the low-skilled has considerably increased. Also noticeable is the relatively strong expansion of the output of services. These observations are consistent with empirical findings on scale and intensity effects driven by immigration

[29] As used in the migration literature, see Ziesemer (2011), we take the World Bank dataset on migration stocks, which provides information on the educational attainments of immigrants and the total labor force. However, the World Bank dataset provides only information from 1975 to 2000, which we use as a proxy.

[30] The computation is as follows: the share of highly skilled immigrants in the U.S. labor force is about 10.91% and in the German labor force about 6.48% in 2000, which makes a difference of 4.43%. Therefore, in scenario (III), the highly skilled labor force has to rise by $44.30\% = 4.43\% \times (N/N_H)$ which gives us a total increase in the medium skilled labor force by $8.80\% = (10\% - 4.43\%) \times (N/N_M)$.

Table 4: Simulation of labor market effects of migration

% changes in	Variables	(I)	(II)	(III)	(IV)	(V)	(VI)
Labor 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	$\hat{l}_M$	10.00	7.12	4.25	-6.95	13.23	8.76
Low	$\hat{l}_L$	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.

(cf. González and Ortega, 2011). They also confirm our stylized facts about the recent increase in the supply of better educated immigrants and low-skilled intensive jobs in many advanced countries.

Furthermore, we see that 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 labor and on the labor market outcomes of the sector-specific labor. Looking at the welfare effects by means of GDP per capita, we obtain the widely observed results where the migration of the highly skilled (scenario IV) is unambiguously beneficial to the receiving country, reflected in an increase of GDP per capita by 9%, whereas the migration of the low-skilled (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%. It is also interesting to notice that in scenario (V) there is a relative decline in the medium-skilled wage rate. This highlights the so-called polarization phenomenon, which might be induced by the recent observed pattern in immigration of better educated workers.

Finally, the most plausible scenario of a migration flow at the higher skill distribution (scenario III), which is dominated by medium skilled workers, has a positive welfare effect, as per capita income rises by 3.75%. This leads 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 labor markets (high-, medium-, and low- skilled) to analyze the impact of various skill compositions of immigration. While the impact of migration flows with different skills on the sectoral decomposition, goods prices, and labor market outcomes for the receiving country has been analyzed separately, to our knowledge, no paper exists that examines the impact of immigration in a general equilibrium framework combining low skilled unemployment and medium skilled downgrading incidence in conjunction with endogenous goods prices. At the same time, the existing literature has paid less attention to the repercussions of medium skilled immigration considering simultaneously its impact on skill downgrading and low skilled unemployment. Our stylized facts highlight the importance of the medium skilled group and the analytical solution of the model verifies that it is able to reproduce these stylized facts. We determined the impact of different migration scenarios on the labor market and the GDP. The following outcomes are at the core of our analysis.

First, we show the role of labor market institutions on the labor market performance of low skilled workers who are mostly vulnerable to economic shocks. In particular, our comparative static analysis reveals that under exogenous unemployment benefits, the low skilled unemployment rate rises together with the incidence of skill downgrading of medium skilled workers in the presence of an inflow of medium skilled immigrants. On the other hand, an endogenous benefit scheme where the low skilled unemployment benefits increase proportionately less than the average of low and medium skilled wages, makes the labor market outcomes of low skilled workers less vulnerable to immigration. Under an endogenous benefit regime, we show that the low skilled wage curve becomes steeper w.r.t. the unemployment rate and derive the labor market policy parameter that characterizes this feature.

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

Furthermore, the endogenous goods prices resulting from price-setting behavior are an important economic mechanism in explaining the substitutability between different types of labor. Our findings reveal that labor migration, irrespective of the skill structure, may also generate a productivity effect for firms by lowering production costs. This in turn explains changes in the skill intensity 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 labor replacement demand, for instance, due to aging.

A Appendix

A.1 Cobb-Douglas production technology

The underlying model used for the simulation is the following.[31]

- Production technology in the manufacturing sector

$$Y_m = K_m^{\nu} H_m^{\alpha} l_M^{1-\alpha-\nu} \tag{A.1}$$

- Production technology in the services sector

$$Y_s = K_s^{\eta} H_s^{\beta} l_L^{1-\beta-\eta} \tag{A.2}$$

- Wage curves

$$w_M = \Phi(\lambda_m, d_M) w_L \tag{A.3}$$

$$w_L = \Psi(\lambda_s, u_L) w_M \tag{A.4}$$

where

$$\Phi(\cdot) = \frac{1}{\bar{\lambda}_m / d_M}, \; \bar{\lambda}_m = \frac{\lambda_m}{1+\lambda_m} \tag{A.5}$$

$$\Psi(\cdot) = \frac{1}{1 + \frac{1-\xi}{\xi\kappa} - \frac{\bar{\lambda}_s}{\xi\kappa u_L}}, \; \bar{\lambda}_s = \frac{\lambda_s}{1+\lambda_s} \tag{A.6}$$

$$\lambda_m = \frac{\delta_m}{(1-\alpha-\nu)(\sigma_x - 1)} \tag{A.7}$$

[31] Notice that this assumption can be seen as the special case of the more generalized CES production function, i.e. $\sigma_j \to 1$, and by defining H_j as a capital input composite produced with a Cobb-Douglas technology.

$$\lambda_s = \frac{\delta_s}{(1-\beta-\eta)(\sigma_x - 1)} \tag{A.8}$$

A rigorous discussion of the properties of the two wage curves and the uniqueness of the wage equilibrium is provided in B. The rest of the model remains as discussed in the main text.

A.2 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 the values for the production side, such as the input shares, as well as for the variables and parameters of our labor market, such as unemployment rates and skill downgrading rates. The parameters are given by (α, β, ν, η, ρ, σ_x, κ, ξ, δ_m, δ_s, λ_m, λ_s). The endogenous variables are (H_m, H_s, l_M, l_L, u_L, d_M, w_H, w_M, w_L, s_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.[32] We also use when necessary different sources to obtain the values for the specific labor market parameters and variables. Table A.1 provides an overview of the calibrated and benchmark equilibrium values. Note that, 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 the cost shares of the low- and medium-skilled workers in each sector. Table A.2 further summarizes the labor market benchmark values.

[32] 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 A.1: 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 labor force (in 1000 persons)[(a)]	N_H	3870
Med-skilled labor force (in 1000 persons)[(a)]	N_M	24043
Low-skilled labor force (in 1000 persons)[(a)]	N_L	10092
Total labor force	$N = N_H + N_M + N_L$	38005
Unemployment rate[(b)]	u_L	0.156
Manufacturing 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
Service 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)]	$\sigma_x = \frac{1}{1-\rho}$	4
	ρ	0.75

(a) Computed from EUKLEMS data base.

(b) From OECD (2007: Table II.A1.1), denoting 2003-2004 average.

(c) From Abraham et al. (2009).

Table A.2: Labor market benchmark values

Description	Parameter/Variable	Value
Skill downgrading rate[(d)]	d_M	0.57
Manufacturing high-skilled employment (in 1000)[(e)]	H_m	1012
Service high-skilled employment (in 1000)	$H_s = N_H - H_m$	2859
	$h = \frac{H_m}{N_H}$	0.26
Med-skilled employment (in 1000)	$l_M = (1 - d_M)N_M$	10339
Low-skilled employment (in 1000)	$l_L = (1 - u_L)N_L + d_M N_M$	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)]	$w_M = (1 - \alpha - \nu) P_m Y_m / l_M$	34.97
Low-skilled wage rate[(f)]	$w_L = (1 - \beta - \eta) P_s Y_s / l_L$	30.73
Labor market policy parameter	$\phi_M = \frac{\xi \kappa w_M}{B_L} = \frac{\xi \kappa w_M}{\xi(\kappa w_M + (1-\kappa) w_L)}$	0.532
Manufacturing trade union bargaining power[(g)]	δ_m	0.137
	λ_m	0.0743
Service trade union bargaining power[(h)]	δ_s	0.087
	λ_s	0.0658
Proportionate factor[(i)]	ξ	0.565
Weighting factor[(i)]	κ	0.50
Manufacturing wage curve	$\Phi(\cdot) = \frac{w_M}{w_L}$	1.14
Service wage curve	$\Psi(\cdot) = \frac{w_L}{w_M}$	0.88
Elasticity of manufacturing wage curve	$\varepsilon_M = -\frac{\partial \log \Phi(\cdot)}{\partial \log d_M} = -\frac{\lambda_m}{1+\lambda_m} \frac{1}{o_M} \Phi(\cdot)$	-0.14
Elasticity of service wage curve	$\varepsilon_L = -\frac{\partial \log \Psi(\cdot)}{\partial \log u_L} = -\frac{\lambda_s}{1+\lambda_s} \frac{1}{\xi \kappa u_L} \Psi(\cdot)$	-1.23

(d) Calibrated to ensure $w_H > w_M > w_L > B_L$.

(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 (A.3) and (A.7).

(h) Calibrated from the manufacturing wage-setting curve (A.4) and (A.8).

(i) Assumption.

B Supplementary Appendix

B.1 Bargaining solution

Recall the Nash bargaining problem

$$\max_{w_i}\{((w_i - \bar{w}_i)l_i)^{\delta_j}\,\Pi_j^{1-\delta_j}\} \tag{B.9}$$

Take logs and differentiate w.r.t. w_i to obtain

$$\delta_j \frac{1}{w_i - \bar{w}_i} + \delta_j \frac{\partial l_i}{\partial w_i}\frac{1}{l_i} + (1-\delta_j)\frac{\partial \Pi_j}{\partial w_i}\frac{1}{\Pi_i} = 0 \tag{B.10}$$

Multiplying the first order condition (B.10) by w_i and rearranging, yields

$$\delta_j \frac{w_i}{w_i - \bar{w}_i} = -\delta_j \frac{\partial l_i}{\partial w_i}\frac{w_i}{l_i} - (1-\delta_j)\frac{\partial \Pi_j}{\partial w_i}\frac{w_i}{\Pi_i} \tag{B.10'}$$

By the Envelope Theorem

$$\frac{\partial \Pi_j}{\partial w_i} = -l_i$$

Thus, the term

$$\frac{\partial \Pi_j}{\partial w_i}\frac{w_i}{\Pi_i} = -\frac{w_i l_i}{\Pi_j}$$

denotes the cost share of labor input in firm's flow profit. In the general equilibrium context, i.e. taking account of goods demand effects, this is given by

$$\frac{w_i l_i}{\Pi_j} = (\sigma_x - 1)\theta_i. \tag{B.11}$$

with θ_i denoting the cost share of labor input.

The first term on the right hand side in (B.10'), $\frac{\partial l_i}{\partial w_i}\frac{w_i}{l_i}$, designates the labor demand elasticity. In the general equilibrium context, this is given

$$\frac{\partial l_i}{\partial w_i}\frac{w_i}{l_i} = -(\sigma_x - \sigma_j)\theta_i. \tag{B.12}$$

Utilizing (B.11) and (B.12) in (B.10') and rearranging, yields the standard wage markup behaviour derived in the main text.

B.2 Unique equilibrium condition under endogenous benefit

We assume that the level of unemployment benefits is tied closely to the average wage. In particular, B_L is defined as a percentage (ξ) of the average of the low- and medium-skilled wages weighted by κ:[33]

[33] 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 services-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 depend only on the parameters of the model. This, in turn, implies that no longer reacts to migration shocks.

$$B_L = \xi(\kappa w_M + (1-\kappa)w_L). \tag{B.13}$$

Using this definition for B_L in (14) and rearranging, we obtain the wage curve (A.4). Note that if the service labor 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 $w_L \to B_L$. Moreover, from (14) and (B.13) 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 5. *A stronger linkage between low- and medium-skilled workers due to wage bargaining 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 and Schönberg, 2009).[34]

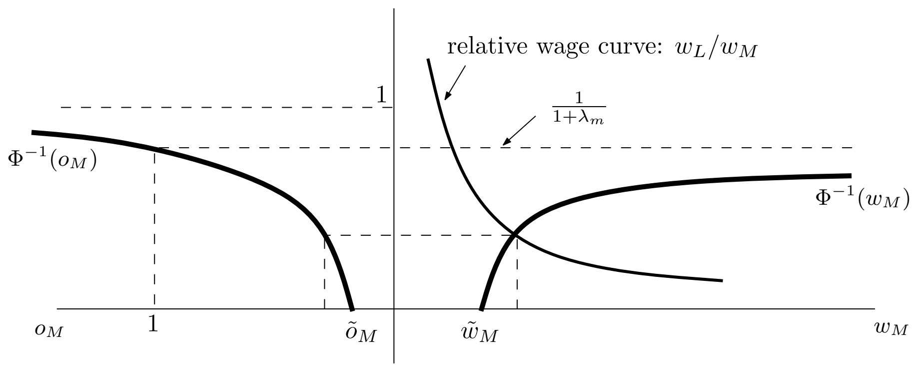
B.2.1 Properties of manufacturing wage curve

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 (A.3) as

$$\frac{w_L}{w_M} = \Phi(\lambda_m, d_M)^{-1} \equiv 1 - \frac{\bar{\lambda}_m}{d_M(w_M)} \tag{B.14}$$

where $\bar{\lambda}_m = \frac{\lambda_m}{1+\lambda_m}$ and $d_M(w_M)$ is given by (11). 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 (B.14) is a decreasing function of w_M but the RHS is increasing for certain values of both o_M and w_M. These relationships are illustrated in Figure B.1.

Figure B.1: Properties of manufacturing wage curve



[34] 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.

Consider first the right panel of Figure B.1. Then, recalling (B.14), we can draw two curves: one shows the negative relation between the relative wage rate due to changes in w_M (LHS of (B.14)) 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 skill downgrading rate and the medium-skilled wage rate as higher wages induces a decline in the labor demand and increase, thus, the risk of downgrading. Recalling the medium-skilled labor demand (6a) and the skill downgrading rate (11), then, one can compute the limiting cases

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

The intersection between the two curves in the right plane will determine the equilibrium skill downgrading rate and the medium-skilled wage rate for changes in the low-skilled wage rate. We conclude

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

Proof. The proof is rather straight forward. Due to the non-negativity assumption of the wage rates, it follows from (B.14):

$$\begin{aligned} \Phi^{-1} &> 0 \\ \frac{\bar{\lambda}_m}{d_M} &< 1 \\ d_M &> \tilde{d}_M \equiv \frac{\lambda_m}{1+\lambda_m} \end{aligned} \tag{B.15}$$

This defines the lower boundary of the skill downgrading rate. ■

B.2.2 Properties of service wage curve

Similarly, the partial behaviour of the service wage-curve can be assessed as follows. First, rewrite (A.4) as

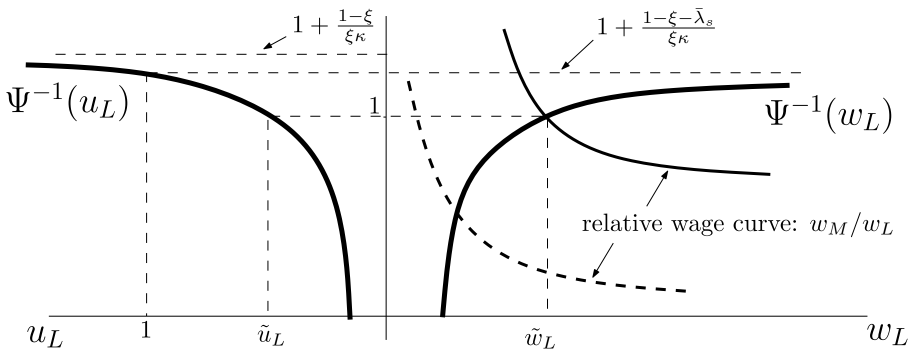
$$\frac{w_M}{w_L} = \Psi(\lambda_s, u_L)^{-1} \equiv 1 + \frac{1-\xi}{\xi\kappa} - \frac{\bar{\lambda}_s}{\xi\kappa u_L} \tag{B.16}$$

where $\bar{\lambda}_s = \frac{\lambda_s}{1+\lambda_s}$. With the same intention described above, we define both the LHS and RHS of (B.16) as functions of w_L for given values of w_M. The argumentation is analogue to the one on 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 B.2, 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 B.2: Properties of service wage curve



Proof. From (B.16), it follows:

$$\begin{aligned} \Psi^{-1} &> 1 \\ \frac{\bar{\lambda}_s}{u_L} &< 1-\xi \\ u_L &> \tilde{u}_L \equiv \frac{\bar{\lambda}_s}{1-\xi} \end{aligned}$$

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 B.1 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 skill downgrading rate which converges to $1 + \lambda_m$, the reciprocal of the limit shown in Figure B.1.

Analogously, the derivation of WC_L can be explained by recalling the RHS of Figure B.2. 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 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 $1 + \frac{1-\xi-\bar{\lambda}_s}{\xi\kappa}$. Notice, 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 B.3, we summarize these conditions and assume that they hold.[35]

[35] In the calibration of the model we show that these conditions do hold for plausible parameter values consis-

Figure B.3: Unique equilibrium

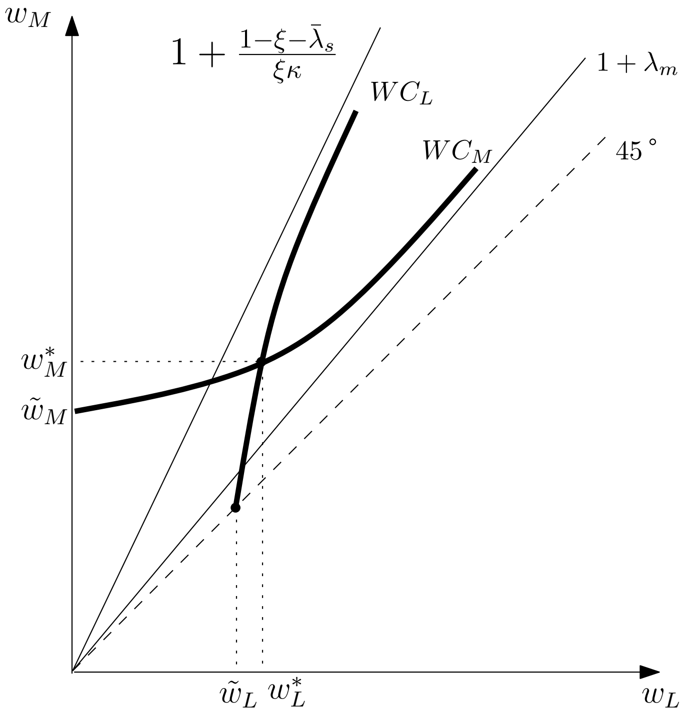


Table B.3: Equilibrium Conditions

Parameter/Variable	Range	Condition
d_M	$\in (\tilde{d}_M, 1)$	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

An illustration of the interdependence relation reveals that a productivity improvement in the manufacturing sector, relative to the service sector, increases the low skilled 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* - 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 coordination of wage formation (Siebert, 1997).

tent with the empirics - see A.

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